PRIMARY (JUNIOR) TEACHING TODAY

VOLUME THREE

PRIMARY (JUNIOR) TEACHING TODAY

GEOGRAPHY

R. K. POLKINGHORNE, B.A. (LOND.)
M. I. R. POLKINGHORNE, B.A. (LOND.)

THE TEACHING OF ARITHMETIC

H. BATES, F.R.G.S.

GEORGE NEWNES LIMITED
CARLTON HOUSE, 66–69, GREAT QUEEN STREET,
LONDON, W.C.2

PRINTED AND BOUND IN ENGLAND BY
HAZELL WATSON AND VINEY LTD
AYLESBURY AND LONDON
F (JB) T.T. 2/H.L.H/53

CONTENTS

GEOGRAPHY

R. K. Polkinghorne, B.A. (Lond.), and M. I. R. Polkinghorne, B.A. (Lond.)

THE TEACHING OF ARITHMETIC

H. Bates, F.R.G.S.

WALL PLATES

FOR USE WITH GEOGRAPHY SECTION

GEOGRAPHY

CHAPTER ONE

INTRODUCTION

As is emphasized in all these volumes, activities are an essential feature of the Primary School. Formal geography is out of place, practical activities are in the forefront, but there must also be material that stirs the imagination and emotion of the child and satisfies a genuine and real interest.

Each school must, of course, plan its own syllabus. In the case of geography this depends to some extent on the environment of the school. The child gets his first ideas of geography from his surroundings and his own experiences.

The actual work to be covered is much the same in all schools, though the approach, details, and arrangement of material may differ. The work to be done falls roughly under four headings:

(1) The *child's environment*—direction, ways of finding direction, weather recording, weather signs; observation and practical geography based on the child's village or town and surrounding country. This goes on through the Four Years' Course.

Linked with this, and also overlapping and supplementing it, is—

(2) *Map-making* and the use of the map, the ABC of geography. Section (1) and this are the most important, and work on them will continue throughout the four years in the Primary School.

(3) *Regional* and *World Geography*.—This includes the position of the home country with regard to the world, and the general arrangement of land and water over the earth's surface, also the understanding of the conditions and ways of life in other lands. Regional geography is best taught by means of these topics of great interest to young children, namely, *Homes*, *Food*, and *Clothing*; world geography by means of voyages. Many of the first lessons in history (see Volume II, History) and the stories of great explorers will help children to realize the relative positions and sizes of the great land masses, and the shape and extent of the intervening oceans. Through lessons on Peoples of Long Ago and stories of early explorers, the children will rediscover the world. The use of the map and globe in the history lesson, and the correlation of history and geography when possible, are important. The history syllabus as planned in these volumes will be found a help to the geography.

The study of Home Geography goes on side by side with the Regional and World Geography; it is not kept to one particular term or year. It has been wisely said, "Every good syllabus should contain in its main divisions, some Home Geography (including maps), some Regional Geography, and some World Geography." It may be asked, when does Regional Geography become World Geography? The simple stories of homes in other lands or regions are just studies of home environments different from the environments of the children; when later the teacher uses the material of these lessons and other lessons as a means of dividing the world into broad climatic regions, the children are really beginning World Geography. Each term the child's growing experiences help him to understand other regions and to compare and contrast them with his own. Without a background of Home Geography the child is handicapped (for Regional Geography see Chapter VII).

(4) *A Study of the Home Lands*, or home country—for example, the British Isles or Australia or whichever country is the home country. The children have by now a sufficient geographical background to begin a more detailed survey of the Home Lands, linked up, of course, with Regional and World Geography.

The coming chapters give suggestions for work under these four headings: (1) The child's environment and practical home geography; (2) map work; (3) regional and world geography; (4) more detailed study of the home country or lands. The teacher can select from each section what is most suitable for his classes and adapt it if necessary.

The NATURE STUDY AND SIMPLE SCIENCE, Volume IV, greatly helps geography. It encourages the child to observe and take an interest in his surroundings. Here the simple facts of astronomy are taught. This is justified by the intense curiosity of children in the sun, moon, and stars, especially at the time of an eclipse. The journey of the earth round the sun, and the cause of day and night, are also dealt with in this volume.

Opportunities should be allowed in each year's work for projects; projects and activities are suggested in the coming chapters. With backward children and very dull children projects are often of doubtful value. They are most successful when suggested by the teacher and guided by her.

So much of geography is practical and interesting that most of the lessons become projects, since they suggest purposeful work for the children. Projects are most often no more than an intelligent way of teaching; they are not an end in themselves but a means to an end. Their value often depends upon circumstances. Projects that succeed in some schools fail in others, and some that succeed in one class fail in another very similar class. Perhaps the best projects are those that children carry on for themselves after school hours. Any lessons that make a child work with more purpose, that make him more alert to link things he learns outside school with things in school, that help him to help himself, are something more than lessons, they are projects to the child because he can see the purpose of his work.

In order to encourage the project spirit, each class should know its syllabus for the term. This is only fair to the children. It is as important in

geography as in history for children to know "where they are going." Details, of course, are not necessary, but children should have some idea of the ground to be covered. The self-help booklets and project booklets suggested in the coming chapters are records of their work which they carry from class to class.

In Volume I, ENGLISH, the relation of geography to literature has been discussed. Folk-tales and travellers' tales are of value, and from time to time in the coming chapters these are suggested. Often they can be read in the English lessons (see Chapter X).

Apparatus and Books, etc.

(1) *Globes and Maps* are essential. The best kind of globe is one that is suspended from the ceiling, that can be pulled down when needed and raised out of harm's way when not in use. This type of globe is only possible if one room is kept for geography. Globes so often get broken that it is worth getting one that is fairly safe from accidents. George Philip & Son supply one that shuts up in a box. The box can be carried from place to place by means of a strong handle. When the teacher wishes to use it, he unfastens the lid, and the sides, which are padded, are let down. A large globe in black and white, which is less expensive, is useful for showing the routes of explorers. These routes can be marked on the globe when needed.

In addition to the globe, two flat maps of the world (on a large scale) are necessary, one in outline that can be filled up as needed. There should also be wall-maps of the British Isles and maps of some of the continents; for example, Africa, North and South America, and Europe.

From the point of view of history as well as geography, a useful map is "a map that grows," so that how the whole world was gradually revealed to the people of the Mediterranean can be shown. Such a map has a faint outline that cannot easily be seen by the class until the coastline is thickened by the teacher. The map would first show the Eastern Mediterranean, where history began (see Volume II, HISTORY, Chapter III); then the Western Mediterranean. Next the voyages of the Phœnicians and Pytheas through the Straits of Gibraltar along the coast of Spain and France to the British Isles. Lastly, the countries definitely known to the Europeans through the conquests of the Romans, the Arabs, and travels of the Crusaders. When the story of Columbus is taken, his route can be marked on the map and the first glimpse of the Americas indicated by the thickening of the lines that show those parts of the coast discovered by Columbus and his men (see Chapter XVII, HISTORY).

(2) *Atlases and Text-books.*—Atlases are more important than text-books. Every child should have the use of a clear, simple atlas that he can browse in at will. He should also be allowed to take it home.

If this is not possible, he should be encouraged to acquire one for home use, and build up a small personal library of his own. But the atlas must be the most important book in the geography period. A good little atlas for work in connection with the British Isles is the atlas of Great Britain and Ireland published by W. and A. K. Johnston of Edinburgh. The maps are very clear and simple. There are maps of the British Isles, including maps that show its position as

one of the countries of Europe, and its economic development in outline. There are also maps that illustrate the main factors in world geography which are studied at about the age of eight. It is essential that some world geography should go on with home geography. "In a very real sense the homeland is measured by other lands." Unless the homeland is seen in its setting, and specially in its world setting, it is not really understood.

Two other useful Junior School Atlases are Bacon's *Junior School Atlas* and Harrap's *New World Atlas*, edited by John Bartholomew. The latter is not so simple as Johnston's *School Atlas*. For reference there should be one or two copies of *The Comparative Atlas*, by John Bartholomew (Meiklejohn and Son). Children enjoy having a big atlas to consult.

With regard to the use of the atlas, it is not enough for the child to use one map only. An atlas that shows one page only well thumbed and the rest almost untouched is an atlas wrongly used. A child, for example, whose home country is Scotland, and who is studying Scotland, needs to consult all these maps in Johnston's Atlas: page 2, the British Isles, to see Scotland's position with regard to the British Isles, and the highlands and lowlands of Scotland; page 13 to show the position of Scotland with regard to the rest of the world; page 14 to show what zone it is in or how near it is to the Arctic Circle or how far from the Tropics—this will help the children to understand the climate of Scotland; pages 8 and 9 for a more detailed study of Scotland, and page 11 to show the position of Scotland with regard to Europe and the steamer routes to Europe across the North Sea. From the beginning, the children must be taught to consult several maps. No country can be properly understood without reference to other countries—"the homeland must be measured by other lands."

Besides the atlas and wall-maps there will be other maps that may have to be made by the teacher, as simple forms of them cannot be found in any atlas. Some of these will be found among the Plates; for example, a map of a river to show a river basin, etc. (Plate III). Although this is a map of the Thames, it can be used for lessons on rivers generally; a simple map of Africa (Plate VIII) to show the hot forests, grasslands, desert—typical regions of the world.

Outline maps will also be needed. In the Junior School these must be provided. Good printed ones can be obtained from most map publishers, or copies can be multigraphed in some way by the teacher. This can be done easily by using the apparatus provided by the Mapograph Company. The maps are printed on a rubber-covered roller which has a very long life, and is worth buying. The Kylography Company has a simpler instrument which reproduces maps quickly and successfully.

Each classroom should have a shelf or shelves of books dealing with the topics included in the syllabus of the class. These the children should be taught to consult for themselves. They will include books with large pictures and easy reading matter, such as *What the World Eats* (Evans), *Other People's Houses* (Harrap), *What the World Wears* (Harrap), and also children's encyclopædias with perhaps book-

markers in the pages that contain appropriate pictures. Besides these books there must be more general geography books—small books brightly written and illustrated that can be used in both the English and geography lessons. As we have said before in Volume I, ENGLISH, the reading lessons must include the reading of some history, geography, and nature study, as well as literature and stories of home life, etc. Many of the books issued by the Edinburgh House Press are good because they are generally written by people with first-hand knowledge. Booklets like the Puffin Picture-books must be included; for example: *On the Farm, Country Holidays, A Book of Ships, Waterways of the World,* etc.; and Puffin Story-books such as *David Goes to Zululand,* suitable for boys of 9–11 years.

There are often a number of supplementary readers issued by publishers that deal with geographical subjects; for example, Nelson's supplementary readers, where India, China, and Tibet provide the background and subject-matter, as *Chandu the Monkey, Mir Baksh the Elephant,* etc. Good stories of animal life are very attractive to children.

Good collections of pictures that are too small for class-work can be mounted to form attractive "brown-paper" picture-books. Children enjoy making picture-books for the library. Questions, notes, titles, etc., under the pictures make them more interesting and useful. Picture postcards and a good deal of interesting literature may be obtained from The Secretary, Imperial Institute, South Kensington, S.W. It is best to write for lists of the guides and pamphlets, etc., so that suitable ones may be chosen. All their pamphlets and postcards, etc., deal with the countries that form the British Commonwealth of Nations. Besides postcards, teachers can purchase at a modest price samples of many of the more interesting commodities produced by the British Commonwealth.

Interesting illustrated pamphlets may also be obtained from the Commonwealth Relations Offices in London; for example, the High Commissioner for New Zealand, 415, Strand, London, W.C.2. Then there are railway guides, often containing beautiful photos, guide-books for various towns and beauty spots issued by town councils, or travel agencies, etc. Useful pictures, pamphlets, and books, and where they can be obtained, are mentioned from time to time in the different chapters dealing with each year's work in the Primary School.

Pictures can be carefully selected to illustrate most points that a teacher wishes to make in his lesson. Suitable captions, notes, and questions are put underneath as necessary. A picture pinned up when needed is of more value than a whole series of pictures shown at once to the children. Among many, the child often misses those the teacher wants him to notice most. The picture, too, may be left up for children to study. Dull children need longer time to grasp a picture than quick ones. (See also Appendix.)

The use of projector lanterns, diascopes, commonly called lanterns, episcopes, epidiascopes. Since a single picture shown during *one* lesson period has much more value than a large number, the lantern should rarely be used in the Primary School for a lantern lecture, or to show a number of

borrowed slides. The place for an extensive use of the lantern might be about once a term for revision.

When new work is being taken, one must go slowly, and one picture at a time is enough. Here the epidiascope is useful. The single picture, diagram, or map may be exhibited for a minute or two in order to make clear one point, or more often it may be left on the screen for a considerable time. When a map is being shown it must obviously be left some time, as children cannot quickly read maps at the Primary School age.

All spectacular or exciting pictures should be avoided, and no picture should be shown that contradicts something already learnt by the children. Exceptions must be dealt with later. Pictures of foreign countries should show scenes of ordinary life, not the "strange sights" seen by travellers.

Some series of pictures are of value when they show the same feature or fact from different aspects, as a picture of the seashore to show high and low tide. Lantern lectures are often unsatisfactory because they show too many *different* things. For pictures to make a good lesson, there should be some relationship between them, some obvious links that the children can see: views of different parts of a river to show a journey down a river, or scenes to show the planting and harvesting of wheat, are of value.

The *cinematograph film* is quite different from the lantern slide or episcope pictures. The film is useful to show movement, and some types of projectors can supply sound accompaniments either in the form of words or natural sounds. The same warning must be given here as for diascopes and epidiascopes: the film must not be long. It must be stopped at times, so that attention can be drawn to the points the teacher wishes to make. Children of the Primary School age need to talk about what they see. There is probably far more in a geography film of, say, 15 minutes (if it is a film of real geographical value) than the children can assimilate by sitting still and looking. The film should therefore be shown in short sections. The fact that action is shown often hinders children from seeing the geographical background. Because of the movement there are many cases when it is better to use other means of illustration; for example, the valleys shown in Plate IV are less suited for films.

Far too many so-called geography films deal with processes of manufacture, details of how things are made, processes which really do not belong to geography. No Junior child can understand or remember them. Tins or loaves, etc., travel along endless belts, wheels turn, bits of machinery are in motion; all this has little real meaning for a child. It is just machinery. Again, the loading or unloading of ships or trains, which lends itself to films, may be of little educational value, certainly of little geographical value. On the other hand, *one* or two good films of the "tools of commerce" or "wheels of industry," for example the crane, the elevator, the tip-up truck, etc., are of value if clear, simple, and short. They teach a child the meaning of the word *machinery*, and increase his vocabulary, but the child must know exactly what the film is illustrating. Some pictures of machinery cannot be explained, even by the teacher! It is difficult to find film strips

that really teach. Probably the best are those that deal with Nature Study and Animal or Insect Life, etc. It is essential that the film fits the geography or nature study syllabus if the film is for teaching purposes; such films as coal-miners at work, or fishermen, are valuable. The miners in their grim, dark underworld and the sound of the pick stir the child's imagination and help to give him a new experience as no words can. Such pictures as these are very different from dull pictures of machine processes. Interesting chapters on the radio and film in education will be found in *Actuality in School,* by G. J. Cons, M.A., and Catherine Fletcher, B.A. (Methuen), Chapter VII, "Radio and Actuality," and Chapter VIII, "Film and Actuality."

Methods of using Films

According to experiments made by Dr. Consett and others, it seems better to give the lesson *after* the film is shown; the children have then some visual impressions to help them to understand the lesson. The film is also best shown in *short sections* in the body of the lesson, unless it is a story in history that would be spoilt by a break. It is also wise to show the film again without a break at the end of the lesson.

There must, of course, be something definite for the children *to observe.* The Primary course in geography is based on the child's own experiences and observations. Pictures make it possible for him to observe people and things outside his environment and in other lands. All pictures, both ordinary pictures, lantern or episcope pictures and films, are of value if they can be used: (1) for observation, *observation that teaches*; (2) as a help to remembering certain facts; (3) to suggest problems to be solved, questions to be asked by the children, and questions to be answered by them; (4) to stir the emotion, to help to show what is beautiful, and above all to kindle interest and ideas. The children must never be passive lookers-on or listeners. The epidiascope or film should not be introduced into schools because they are modern. Good pictures are often as useful as films, if not better. In the Primary School the film must be used with discretion, always remembering that it should rarely occupy a whole lesson.

Broadcast Lessons

These again are less fitted for the Primary School than for the Secondary School. Most of the lessons given on the wireless could with far greater advantage be given by the teacher who knows her class, when to stop, when to ask questions, and so on. Children are far more likely to be impressed by the voice of a living teacher than the voice from a box. It is important, too, that the child should be able to interrupt by questions when necessary. The wireless is a mixed blessing both at home and at school, because it tends to make people passive listeners.

Young teachers, too, will miss a great deal if they come to depend on the wireless for their lessons. The preparation of lessons can be both a pleasure and a profit. Only in certain cases are wireless lessons really of value—to listen to beautiful music, or a special song, or some talk by an expert.

CHAPTER TWO

HOME GEOGRAPHY

HOME geography is the geography of personal experience, and as much home geography as possible should be carried out in the open air. The beginning of local geography lies in nature study. Every school should accustom its children to observe the sun, moon, and stars, the wind and rain, frost and snow; shadows shortening and lengthening during the day and as the year goes on; the changing seasons—the pageant of bud, leaf, and flower in parks, gardens, fields, woods, and lanes—to observe, too, the natural law as illustrated by the movement of the earth, sun, moon, and stars; day, month, and year, and the movements of the tides.

In the cities something of the pageant of the seasons can be seen in pots, bowls, and vases indoors, and in changing shop windows. One can begin almost as well from the city streets and shops and arrive at the fields, farms, and hedgerows as proceed in the opposite direction. The great point is that at all stages opportunity should be given the children to learn something about the life of the country and the life of the town—as well as the seashore and the sea. Much of the above work is covered by NATURE STUDY AND SIMPLE SCIENCE, Volume IV.

In towns, local geography may begin with the study of streets, how law and order are illustrated by the naming of streets, and the numbering of shops and houses; where the streets and roads lead. Transport—where all wheeled things are going and on what errands; tramway and bus systems. The main railway stations and where the trains go. The materials used for building houses and where they come from—quarries, brick-fields, and forests. Main industries of the city, or part of the city, town or village as the case may be. Shops and their contents, and where these come from, and so on (see coming chapters).

No text-book can cover local or home geography, because the surroundings of each school vary so. The best plan is to let the children build up their own geographies. Here we will deal mainly with work that can be carried out wherever the school happens to be, and give factual information of a general character that applies to all districts, and which all children should know, wherever their school is situated.

First the children must know something about direction or finding their way.

Direction or Finding One's Way

Talks about the way to school, the things passed on the way, etc., are important as an introduction. Ask the children how they find their way to school, the names of the streets and landmarks passed, such as churches, libraries, stations, etc. They can name

everything that helps them to find the way.

Now supposing they were lost on a lonely moor or in a wood, how would they know which way to turn or in what direction to go? If lost in the streets, what does one do? How did men find their way about when there were no policemen, no signposts, no milestones, no streets, and no roads? In their history lessons the children are learning about the long-ago times. (See Chapters II and III, HISTORY, Volume II.)

Direction by the Sun

(See also Nature Study, Volume IV)

Long ago men first found direction by noticing that daylight began on one side of the sky which was called the *east*, and that the sun went down on the opposite side which was called the *west*. All over the world the sun *seems* to rise in the east and set in the west. Long ago the men in Britain noticed where the sun was when it was highest in the sky. This part was called the south. The north was the part of the sky where nothing happened.

Let the children try to find east and west, north and south for themselves. Are there any rooms in their house or the school that *never* get the sun? Which rooms get the morning sun? The evening sun? In which direction does their home or school face? Which is the sunniest part of the garden? It may take the children a little time to learn what is meant by east and west, north and south. During the winter months, especially in December and January, the children will often be able to watch the sun set, either on the *horizon* or behind some houses. Let the children make notes of where they have seen the sun set.

The sun makes an arch in the sky, as it seems to travel from east to west. Let the children make a diagram, as in Fig. 1, to help them to remember that the sun seems to travel from east to west, and where we see it when it is highest in the sky; also a picture of sunset at sea (Fig. 2) for the word *horizon*, the line (AB in Fig. 2) where earth and sky seem to meet. The horizon can be seen wherever the country is flat and open, and at sea. The children will learn more about the sun and its movements in the SIMPLE SCIENCE SECTION, Volume IV.

Direction by Sun and Shadows

Another way of finding direction is by shadows. Take a pole and set it upright in the playground, or in some open place away from the shadows cast by houses or trees. A netball goal-post is the easiest one to set up, but a broom handle or a scout pole or any long stick can be fixed in a pail of sand or in the ground. Let the children watch the shadows cast, the direction in which they point, and when they are short or long. They enter any facts they notice in their note-books, and have a day or time for discussing their notes. Then

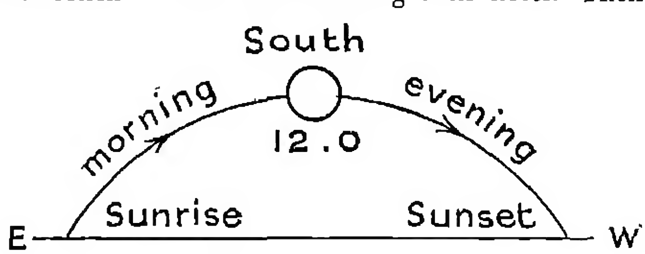


Fig. 1.—PATH OF THE SUN

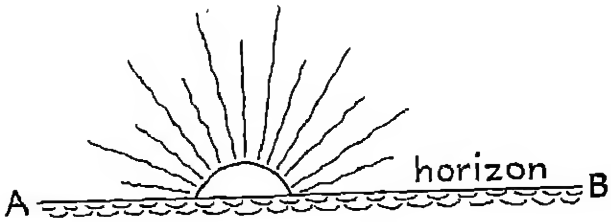


Fig 2.—SUNSET AT SEA. THE WEST.

give them something definite to do; for example, on one fine day mark the direction and the length of the shadows at each fifteen minutes between 11.15 a.m. and 12.30 p.m. (Greenwich time. One hour must be added for single summer-time). They measure the length of each shadow, and enter it in their notebooks with the times by the side. What do they notice?

(*a*) When the shadow is *shortest* it is *noon* by the true or sun time. (*b*) When the shadow is shortest the sun is in the south and the shadow points *due north*. Produce the line cast by the shadow in the opposite direction. Which way will the line point? How can the east and west be found? (Fig. 3.) (*c*) The *higher* the sun is in the sky the shorter the shadows are and the hotter it is. This is an important fact for the children to remember. It will help them to understand later why it is so hot at the Equator and in the tropics.

Shadows through the Year

Let the children keep their shadow records for each month at noon, so that they notice how the noonday shadows lengthen as the winter comes on. What makes them lengthen? The sun is lower in the sky.

Town children hardly notice their shadows in the winter, partly because of the many buildings which hide the sun and partly because the light is so dim and the shadows are so long that they are much less noticeable. In summer the shadows are smaller and darker. The children notice that their shadow-stick helps to tell the time, for the morning and afternoon shadows point in different directions. The sundial is a shadow-clock. The children will think of the shadow-clock of Egypt (see Volume II, HISTORY), the oldest clock known. Fig. 4 shows a sundial. (More about Time and Timekeepers will be found in Volume IV, NATURE STUDY AND SIMPLE SCIENCE.) The children in the upper class might be able to make a sundial. Directions for making a simple horizontal one will be found in *Projects for the Junior School*, Book III (Harrap).

Simple Direction Card or Compass

The children cut round cards as in Fig. 5, and mark on them the four chief directions, or as sailors call them, " the four chief *points* of the compass," N., E., S., W. These four points are sometimes called the *cardinal points*. The children cut out of cardboard or stiff

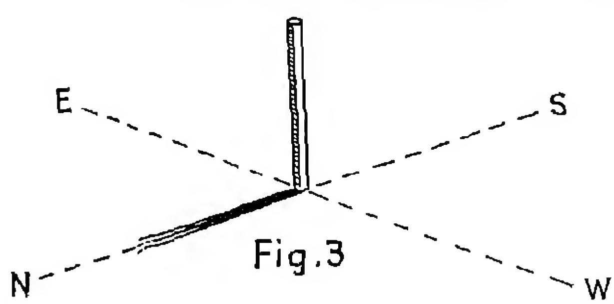


FIG. 3.—FINDING THE NORTH BY A SHADOW-STICK

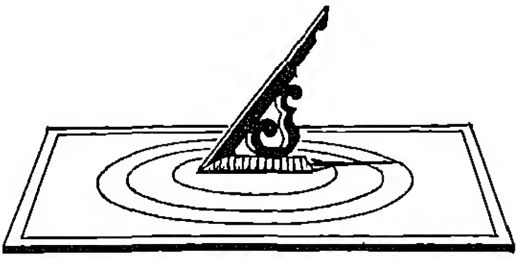


Fig. 4.—Sundial.

paper pointers or hands, as in Fig. 5. These are fastened to the centres of the cards with self-piercer paper fasteners, so that they turn freely. With these the children find the direction of objects (*a*) in school, (*b*) in the playground, thus:

The card is placed on a table so that the letter N. on the card points to the real north. A child names something in the room to the north, then turns round and names something to the south, to the east, to the west. The pointer is turned to point to different things and the direction read. They learn that when the pointer is half-way between north and east, it points *north-east.* They turn the hand to point *south-east, south-west, north-west.* These points are added to their compasses to make eight (Fig. 6). For everyday purposes, telling the direction of the wind, etc., we only use these eight.

The children set their compass-cards correctly—North on the card pointing north—to name the walls of the room, and the corners (Fig. 7). The hand is moved to trace out the sun's path—east, south-east, south, south-west, west. When the hand is turned in this direction, it is turned in sun-wise fashion or clock-wise, that is in the same way or direction as the sun moves or the hands of a clock move. The children say the names of the points "round the clock"

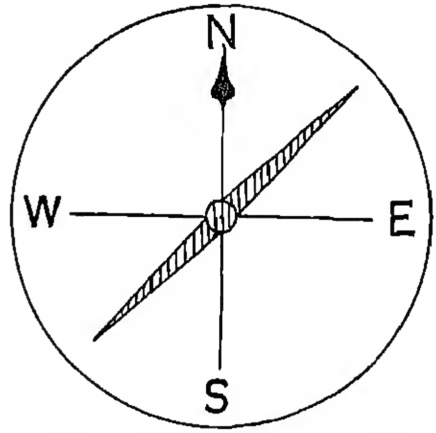


Fig. 5.—The Four Chief Points of the Compass

or clock-wise, starting with the east. They use their compass-cards in the playground to find the direction of six things. Give the children some questions like these to answer:

(1) A fisherman rowed his boat westwards. In what direction will he return?

(2) The direction from London to Liverpool is N.W. What is the direction from Liverpool to London?

(3) Fig. 7 is a square that represents a room facing north. The children draw it and write on it the names of the walls. Then they name the corners,

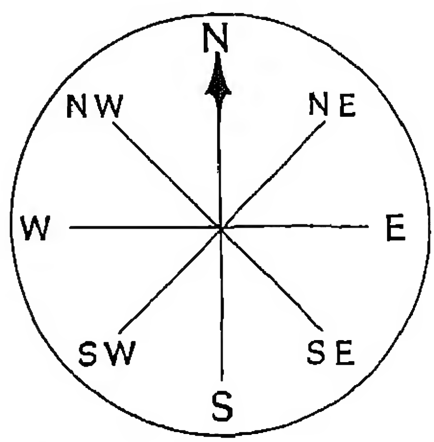


Fig. 6.—Eight Points of the Compass

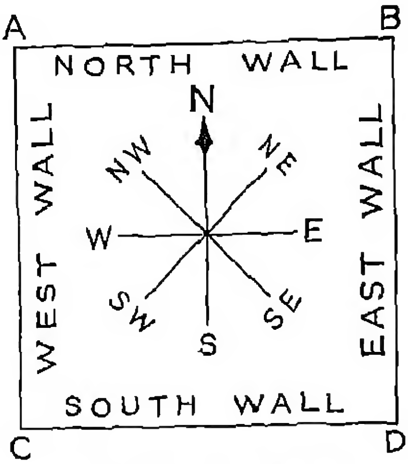


Fig. 7—A Room facing North

thus: A, the N.W. corner, and so on. (Their compass-card will help them if they place it as in Fig. 7.)

(4) Draw your classroom and name the walls. To do this, place your compass-card in the centre of the room and set it correctly—north on the card pointing to the real north. Which wall has the most windows? Which wall or walls has no windows? In which part of the room is the door?

(5) Draw an imaginary room that faces N.W. and name the walls and corners. Your compass-card will help you to do this if you place it in the centre of your drawing so that N.W. on the card points to the middle of the wall marked N.W. What is the opposite direction to N.W.?

Direction by the Stars

(See Nature Study, Plate X)

Besides the sun, the stars were a great help in finding direction before the days of the mariner's compass. The Phœnicians found their way by the sun and the stars, as did the Arabs of the desert (see History, Vol. II).

Let the children tell what they have noticed about the night sky and the stars. The stars do not look all the same size, their colour varies too, and some of them do not seem to twinkle. The easiest and most important group of stars for children to pick out is the group of seven stars called the Plough, Bear, or Wain (Wagon), Fig. 8. Let the children find them on the Star Map, Plate X. The children can decide whether the seven stars look most like a plough or wagon. There are three stars that look like the handle of the plough, or perhaps they are three horses drawing a wagon. The Americans call these seven stars the Dipper. It is easy to see the long handle (3 stars) and the cup (4 stars) of the Dipper. It is far more like a dipper than a wagon or plough. Two of the stars in this group (Fig. 8) are called the "Pointers," because they point to the North Star and help us to find it.

When we face the Pole Star, we are looking north, and as this star never changes its position, it is a very useful guide to sailors when there are no clouds. Although the North Star is always in the same place, the Plough varies its position because it circles round the North Star as shown in Fig. 9. The Pole Star is directly over the North Pole, and it is the only star in our sky that does not seem to move.

Show the children the North Pole on the school globe. (In their science lessons the children will learn about the rotation of the earth on its axis and the terms North and South Pole, see Volume IV, Nature Study and Simple Science.) Remind them that on the school globe (and on the earth itself) there are two points exactly opposite to

each other called the North Pole and South Pole (Fig. 10). Half-way between them a line is drawn on the globe called the Equator, dividing the surface into two equal parts called hemispheres (*hemi-sphere* is a Greek word meaning *half a sphere* or half a ball. The children learn about Greek words in Volume II, HISTORY, Chapter IX)—the Northern Hemisphere and Southern Hemisphere. The diagram Fig. 10 shows the position of the British Isles. The British Isles are in the Northern Hemisphere; they are north of the Equator. It is only the people who live in the Northern Hemisphere who see the North Star, because it is over the North Pole. The people who live in the Southern Hemisphere see other groups of stars, such as the Southern Cross. The Southern Cross is shaped something like a kite, and the people of Australia, Tasmania, and New Zealand can find direction to the south at night by looking at it. A line through the middle of the kite (Fig. 11) points to the South Pole. The Southern Cross has been put on the Australian flag. We never see the Southern Cross, and the Australians never see our Plough.

The children make a drawing of Fig. 10 for their booklets about Direction.

They can be told now that the coldest parts of the world are around the poles, and the hottest parts on or near the Equator. Later the children will learn more about the hot and cold lands (see Chapter VII). The children will learn about some other groups of stars in the Simple Science lessons (see Volume IV) Stories for the youngest classes about the Dipper and the North Star, and other groups of stars, as well as the moon, to interest them in the night sky, will be found in *A Tale in Everything* (U.L.P.). A better way of finding direction than by the sun, shadows, moon, or stars, was by the mariner's compass which we still use today.

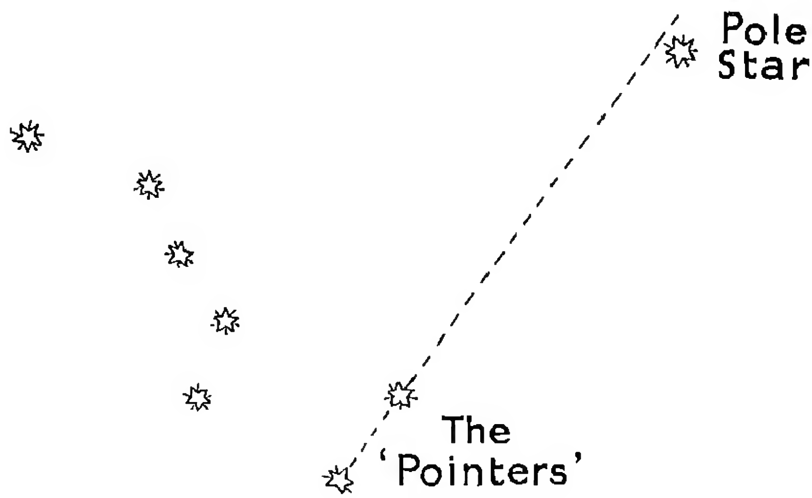


Fig. 8—HOW TO FIND THE POLE STAR. FIND THE GREAT BEAR OR PLOUGH. AN IMAGINARY LINE JOINING THE 'POINTERS' AND CONTINUED INTO SPACE PASSES VERY NEAR THE POLE STAR.

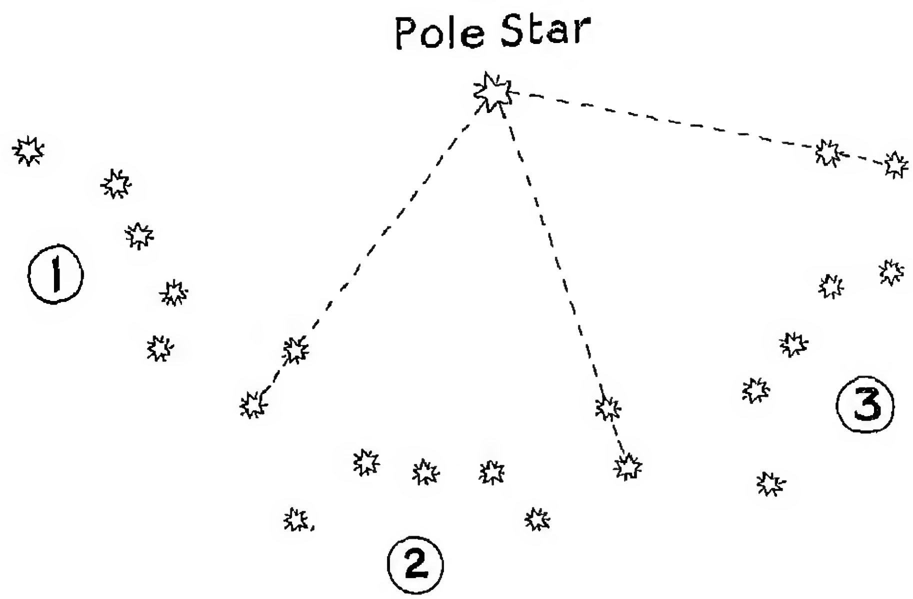


Fig. 9.—The Pole Star and the Great Bear or Plough. How the Great Bear revolves about the Pole Star. Changes in Position at Intervals of Four Hours. Note the Angle.

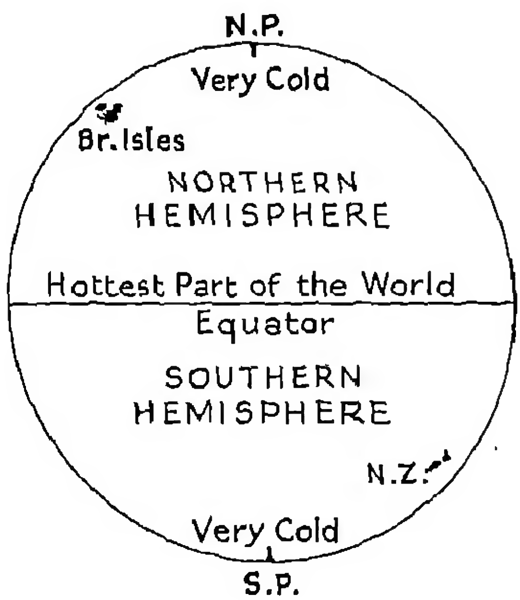


Fig. 10.—The Equator and the Poles

The Mariner's Compass: what it is, how it works, what it does

(Figs. 12 and 13)

Sailors steer their ships by the mariner's compass. If possible, a large compass should be shown to the class. Let them examine it and take it to pieces to see how it works. Small pocket-compasses are useful. Many children are so interested in the compass that they save up their pocket-money to buy one. They use the compass in the classroom and playground to find the direction of given objects. They learn the sixteen points of the compass (Fig. 12) and add them to their own cards. The new points are easily made from the eight points, thus: between N. and N.E. comes N.N.E.; between the N.E. and the E. is

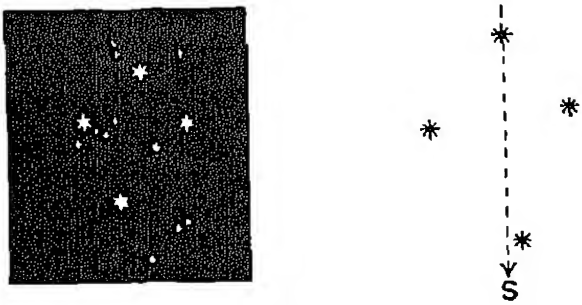


Fig. 11.—The Southern Cross pointing to the South Pole.

E.N.E.; between the E. and the S.E. is E.S.E. and so on.

The children say the names "round the clock" (clock-wise), starting with east, and pointing to the directions round the room. Give them questions like these: What is opposite to N.E., N.N.W., W.S.W., E.S.E.?

If possible, take the children out to some high view-point in order that they may take the compass bearings of various landmarks.

The mariner's compass has thirty-two points. These are made from the sixteen points by adding the "by-points" (Fig. 13). They are too many for landsmen to learn, but sailor boys have to learn to "box the compass," that is, to be able to say the points in order (sun-wise) right round the card. In stories of travel the by-points are sometimes mentioned, for they are needed when travelling in strange and difficult country, and at sea.

The mariner's compass links up with history (see Volume II), which tells when the compass was first used and who thought of it. What makes the needle point north? Long, long ago there was discovered in Asia Minor a wonderful stone that could attract and pick up pieces of iron. The name given to it was *lodestone* or *magnet*. (Remind the children of the iron region of the Hittites in Asia Minor and let them find Asia Minor on the map.) (See History, Volume II.) Later it was discovered that if a piece of steel was "stroked" with a piece of lodestone it, too, became a magnet. Later still it was found that if a magnetic needle was floated on a bowl of water or oil with the aid of a straw or stick, it behaved in a wonderful way—it always turned so that one end pointed to the north and the other end to the south. The floating magnet was the first compass.

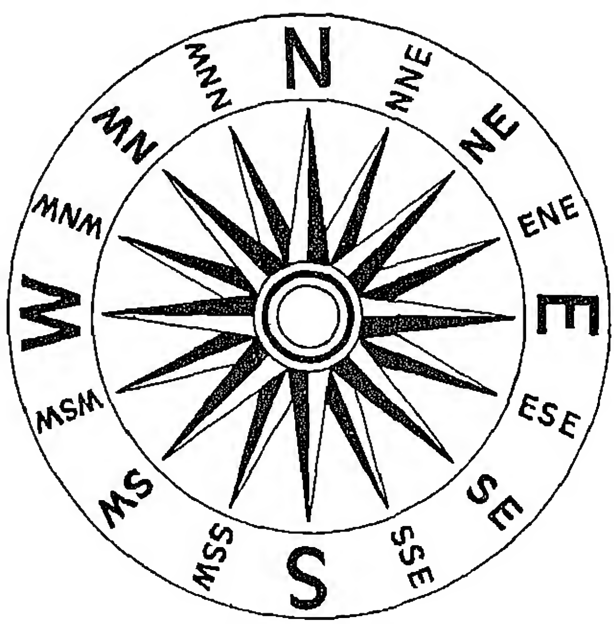


Fig. 12—Sixteen Points of the Compass.

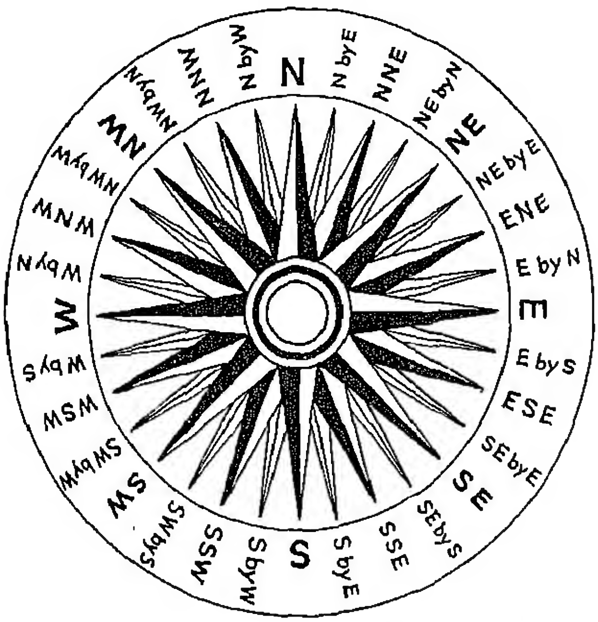


Fig. 13.—Mariner's Compass—Thirty-two Points.

The children will learn more about magnets in Volume IV, Nature Study and Simple Science.

The children like to make booklets about Direction. They can make a list with drawings of all the ways of finding direction: (1) at *noon* by observation of shadows, (2) by night in the Northern Hemisphere by observing the Pole Star, (3) by night in the Southern Hemisphere by observing the Southern Cross, (4) at any time and in all weathers by means of the magnetic compass. To these the children can add, (5) by day, at any time, by means of *sun and watch*. This is the Boy Scout's way—lay your watch on its back so that the small hand (the hour hand) points in the direction of the sun. Then imagine a line going from the centre of the watch to the number 12. Half-way between this line and the small hand is the south—that is, a north-south line bisects the angle between the hour hand when it points to the sun and the line joining the centre of the dial to twelve. The explanation can be given *later*. The sun takes twenty-four hours, or a day, to travel round the earth (it is, of course, really the earth that rotates on its axis), but our clocks are marked for twelve hours only, so the hour hand has to go round *twice* to complete a whole day. It therefore travels *twice* as fast as the sun. Suppose the hour hand points to the sun in position A (Fig. 14) at noon; it is pointing due south. At 4 p.m. the sun will be in position B—i.e. opposite 2 o'clock. If the watch is turned round so that the hour hand points to the sun as in Fig. 15, it is clear from the figure that the line bisecting the angle between the two hands passes through A—i.e. it is the north and south line. Of course the minute hand is not always at 12 on the dial; when it is not, the north and south line bisects the angle between the hour hand and the line joining the centre of the dial to 12.

Children will be interested to know that some countries have a "twenty-four-hour clock." Then the hours after midday are not called 1 p.m., 2 p.m., etc., but 13 o'clock, 14 o'clock, and so on until midnight, which is 24 o'clock. Children interested in clocks will learn more about them in Volume IV, Nature Study and Simple Science.

In their Direction book, the children can write all that they learn from the

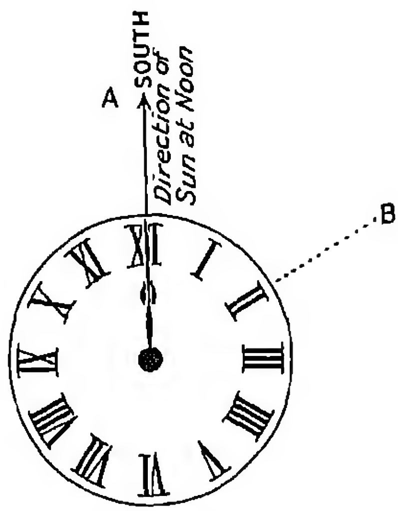


FIG. 14.—WATCH WITH THE SMALL HAND POINTING TO THE SUN AT NOON.

shadow-stick. The children also make a geography word-book for new words learnt: cardinal (chief), horizon, lodestone, etc.

Quizzes.—Thoughtful questions may be compiled by both teachers and children as—(1) If an airman is flying over the North Pole, where will he see the Pole Star? (2) Why does the hour hand move twice as fast as the sun? (3) As you face the sun, towards which hand does it move? (4) Without looking at the compass, say the points in order beginning N.N.W. (5) In which direction does your shadow point when the sun is in the S.E.? At what time of the day is that? (6) When is the sun in the S.W. part of the sky? (7) Which wind will blow ships to the N.E.? (8) In which direction does your hand travel as you write? In which direction does it return? (9) On which side of the sky does the sun rise? On which side does it set? (10) How can you find which wind is blowing? (11) What kind of weather do we generally get with a north wind, south wind, south-west wind? (12) How many points has the mariner's compass? Which are the points on each side of S.? (13) How does the Pole Star differ from the other stars in the sky? How can you find the Pole Star? (14) Name a group of stars that we never see at all in Britain. (15) When does the wind veer?

The Wind and Direction

Winds are named according to the direction from which they blow; thus the south wind blows from the south, the north wind from the north.

As soon as children know the cardinal points and can readily tell direction by sun and compass, they should begin to notice the direction *from* which the wind is blowing, and with help they should begin to keep very simple records.

Every school should have a large *wind-vane* or weathercock perched high so that it is visible to children in the playground. If the school has no

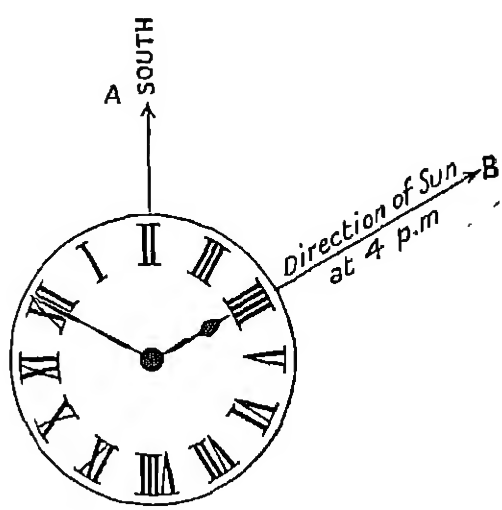


FIG 15.—SMALL HAND POINTED TO THE SUN AT 4 P.M.

weathercock, there may be one on a church spire or high building near the school which the children can observe as they pass. (Advice as to home-made weathercocks will be found in Volume IV, NATURE STUDY AND SIMPLE SCIENCE.)

Children can find or think of other things that help to tell them something about the wind—the smoke from chimneys, fluttering flags, bending trees, leaves, drifting clouds.

If a chimney can be seen from the window, this experiment may be tried: lay a ruler on the window-ledge or on a table in the window pointing in the direction in which the smoke is going. The direction is named by the walls of the room or by the sun. If the smoke is going south, then a north wind is blowing. Some children may find this method easier: draw the four cardinal points on a piece of paper, place it on the table in the correct position, lay a pencil or pen across the paper showing the direction in which the smoke is blowing. Children enjoy this rhyme about wind and weather:

CHIMNEY-TOPS

Ah! the morning is grey;
And what kind of day
Is it likely to be?
You must look up and see
What the chimney-tops say.
If the smoke from the mouth
Of the chimney goes south,
'Tis the north wind that blows
From the country of snows;
Look out for rough weather,
The cold and the north wind
Are always together.
If the smoke pouring forth
From the chimney goes north,
A mild day it will be,
A warm time we shall see;
The south wind is blowing
From lands where the orange
And fig-trees are growing.

From *Little Gem Poetry Books*, Book I (Bell).

Naming the Winds

As the winds blow from many different directions, they have many names. If the children look at their compass-card that has eight points (Fig. 6), they can name eight winds. They name these winds, beginning with the north wind, and going round the compass clock-wise or sun-wise.

When the wind changes its direction from N. to N.E., or from N.E. to E., that is clock-wise, it is said to *veer*. In Fig. 16 the arrows outside the circle show from which direction the wind is blowing, the arrows on the circle show how the wind changes when it *veers*. When the wind changes in the opposite direction, it is said to *back*. Thus it backs from E. to N.E., and from N.E. to N. (Fig 17). Of course the wind does not always blow from one of these eight directions. Sometimes, for example, it veers slightly east of north but not so far as north-east, perhaps N. by E. on the mariner's compass. But when a landsman talks of the winds he finds the eight directions enough. As a sailor has thirty-two points on his compass, he can tell more exactly from which direction the wind is blowing. Children who read sea stories or speak to fishermen and sailors must look out for the words *veer* and *back*. They may find in their books the expression "the wind veered a point," a point meaning one of the thirty-two points of the mariner's compass.

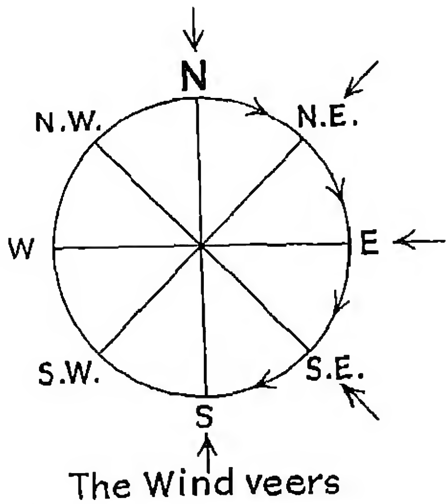


Fig. 16.—Wind changes from E. to S.E. to S etc

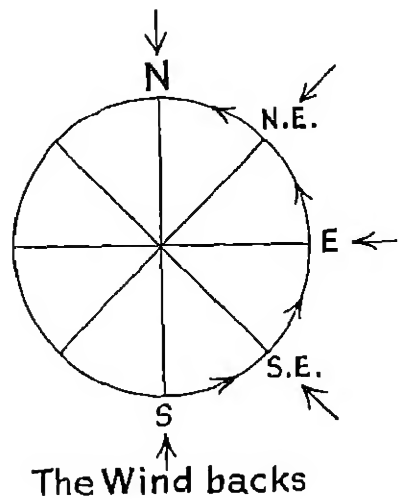


Fig. 17.—Wind changes from S. to S E. to E. etc.

The First Simple Record: A Wind Chart (Fig. 18)

Fig. 18 shows a very simple wind chart. The heading "Where the wind comes from" is important. If children are taught from the first to think of the direction *from* which the wind blows, they will never be confused as to whether a westerly wind blows *from* the west or *to* the west. Let them get accustomed, too, to using the compass in finding wind-directions, not the sun. The geographical north as found by the sun is slightly different in position from the magnetic north found by the magnetic needle.

From this first simple record card the children get much valuable practice, especially if the finding and recording of the direction of the wind is a daily one carried out when school begins or at some fixed time.

As soon as possible let them make use of their records. After a week or two, they may find out that the winds that blow most often are those that blow from the west or "have some west in them," as N.W. or N.N.W. The word *Westerlies* can then be taught, and there is little danger of the children falling into the error of thinking that "westerlies" are winds from the west only. The word "westerlies" includes all winds that "have any west in them."

Booklets about the Wind

Children will enjoy making booklets about the wind. One booklet may be called "The Work of the Wind," and show in pictures and words all the things the wind does. It is surprising what a long list the children can make. Then there are sounds made by the wind, the names of the winds, and all the other facts the children have learnt. The booklets may be made like those described in Volume I, English. A picture of a windy day, etc., is drawn on the cover. The booklets should not be very large, especially in the lower classes.

Days of the week	Where the Wind comes from
Sunday	W.
Monday	N.W.
Tuesday	S.W.
Wednesday	S.W.
Thursday	N.W.
Friday	N.
Saturday	N.

Fig. 18.—Simple Wind Chart.

Wind and Weather

The daily recording of wind direction can be combined with observations and records of weather. There are no hard-and-fast rules regarding wind and weather, but the children may keep their simple records long enough to establish some of these facts:

(1) Westerly winds are most often *wet winds* or winds that bring some rain; easterly winds are often *dry winds*—but sometimes bring rain.

(2) The north wind is cold, the south wind warm.

(3) The south-west wind blows more frequently than others in Britain. It *usually* brings mild and wet weather.

(4) The north-west wind is cold and wet and brings snow sometimes in winter.

In winter and spring the east wind is cold as well as dry, and "goes right through one."

The two factors besides the wind that children should consider with regard to *weather* are (1) rain, steady rain, showers, or fine and dry; (2) temperature (not at first using the word "temperature"), is it warm or cool, hot or cold? Fig. 19 shows a useful record. Some children in the lowest classes may like to make pictorial weather charts as they did in the Infants' School — thick slanting lines for steady rain; dotted lines for drizzle; a sun for a fine sunny day; *and so on*. These often look very effective.

A wind-rose (Fig. 20) is a useful and pleasing way of keeping a record. It has eight arms, each representing a wind, but each arm is made up of oblongs or squares, each representing a day. Each day at the same time the children look at the weather-vane and also notice the weather. Then they colour a space on the right arm, red or yellow for a sunny day, grey for a dull day, and black for rain. The children will notice that most of the wet days occur when a west or south-west wind is blowing, and that the south-west wind is the wettest wind of all. At the end of the month a child may be chosen to write a little summary of the weather of the month.

In the upper classes pupils may like to make very accurate charts for the wind only. They draw lines for the arms, making each line about three inches long; they divide each line into sections of ¼ inch. Each day at the same time they notice the direction of the wind, and write the date by one of the sections on the proper line. The observations may now be made three times a day; for example, at 9 a.m., 1 p.m., and 5 p.m. The wind changes sometimes during the day. Each day

Days	Wind	Wet or Fine	Hot or Cold Warm or Cool
Mon.	S.W.	Showery	Warm.
Tues.	W	Heavy Rain	Cool.
Wed.	N.W.	No Rain – Dull	Cold
Thur.	S.	Fine – Sunny.	Hot

Fig. 19—Simple Weather Chart.

will therefore have three entries. The entries for the third of the month will be: 3.9 a.m., 3.1 p.m., 3.5 p.m. At the end of the month the children find the *prevailing* wind. *Prevailing* is a good word for them to learn. Winds have been observed in London and other great cities for many years, so that people in these places know pretty well what winds to expect. Even so, the weather is full of surprises.

In their science lessons (see Volume IV, Nature Study and Simple Science) the children will learn about weather, evaporation, water-vapour, condensation, rain, etc., but it is not to be expected that one lesson is sufficient. Everything is so new to the children that they have to learn these new things many times. Lessons on the same topic, slightly different and from different points of view, given in the nature lessons and geography lessons help children to become at home with difficult words and ideas. A lesson on evaporation, condensation, and rain might be given in the geography lesson in this way·

Let us find out where the water

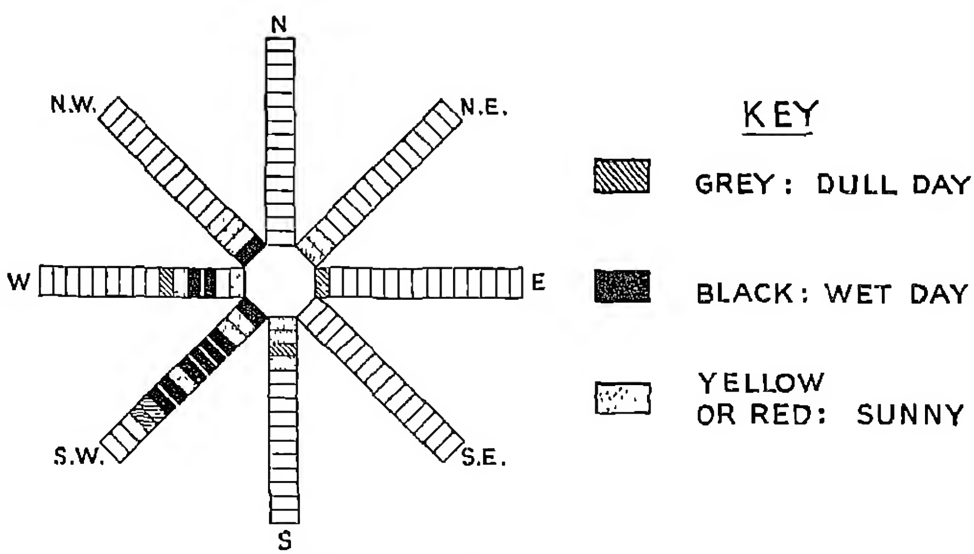


Fig 20.—A Wind- and Rain-rose.

comes from that makes the rain-clouds. Place some water in a saucer and leave it for a few days. After that time you will notice it has disappeared or dried up. Where has it gone? It has really only changed its shape; it has changed from water into water-vapour. This vapour is so light that it moves with the air and we cannot see it. This change from water into water-vapour is called *evaporation*. Evaporation takes place when roads dry up or clothes dry—that is, the water in the pools and clothes passes into the air. We must remember that wherever there is water, evaporation is always going on, although we cannot see it. Think, therefore, how much evaporation must take place from the lakes, the rivers, and the seas, and you will understand there is always moisture in the air, and sometimes a great deal.

Now let us think how the water-vapour in the air gets back again and becomes water. One way to get some water out of the air is by cooling it. Get a small piece of ice from the fishmonger and put it in a glass half-full of water. The ice cools the water, the water cools the glass, and the glass cools the air around it. Notice the outside of the glass. It has become misty. Touch the glass and it feels damp. It is covered with very, very tiny drops of water that have come from the air. Sometimes on a cold day mist forms on the inside of the window-pane. When invisible water-vapour in the air changes to water we say it *condenses*, and the change from water-vapour to water is called *condensation*.

Now you can begin to understand how fogs and clouds are formed. When damp air gets cold the vapour *condenses* on every little speck of dust floating about. This makes the specks bigger and they can be seen; so we get a cloud of tiny specks of water each with a much tinier speck of dust inside—a *fog*. Fog, mist, and rain-clouds are really masses of very tiny drops of water so light that they float in the air and can be driven along by the wind. If the air gets warm, they dry up and become vapour again. If a cloud gets colder, more little drops of water may be formed so that the tiny drops join together to make bigger drops. Then the big drops become too heavy to float in the air and fall as rain.

Have you ever heard people speak of dry winds and wet winds? What do you think they mean? Which winds are most likely to bring rain: those that blow over the sea or those that blow over the land?

In both their simple science lessons (Volume IV) and geography lessons, the children should be encouraged to look at and enjoy the lovely shapes of the clouds, and learn to know the colour and shape of those that bring rain. Older children may learn the names of the clouds (Plate VI, NATURE STUDY). They will enjoy studying the picture of the clouds on this plate. Many children like to make booklets about "Clouds I Know," or "Clouds I have Seen." In their art lessons they paint "sky pictures," especially in the spring.

Easy stories about clouds, wind, rain, frost, weather, etc., for the first-year classes will be found in *A Tale in Everything* (University of London Press). These will help to interest the duller children in the things they see around them. Children should also be encouraged to collect weather sayings and proverbs and notice if they are

always true, also rhymes about the weather, seasons, and months. Some will be found for each season and month in *Little Gem Poetry Books* (Books I—IV, Bell). Here are some weather sayings and proverbs:

The wind from the east is neither good for man nor beast.

February fill dyke (ditch), rain half the day and half the night.

A red sky at night is the shepherd's delight, a red sky in the morning is the shepherd's warning.

Rain before seven, fine at eleven.

St. Swithin's Day, July 15th:

St. Swithin's day, if thou dost rain
For forty days it will remain.

Fine weather in June sets corn in tune.

Ne'er cast a clout till May be out.

March many weathers.

March comes in like a lion and goes out like a lamb.

(Other interesting proverbs will be found in Volume I, ENGLISH, Chapter X, "Literature.")

Direction again. Where is the West?

Using their compass, the children can make a chart like that shown in Fig. 21 to show the direction of some places or things around the school. They may be able to find more things to put in their direction chart if they look from an upstairs window. Some schools are so shut in that little can be seen from the playground. Walks can also be taken to some high place, and a chart made to show the direction of interesting places around.

WHERE IS THE WEST?

When teaching direction to the lower classes, there is always the danger that they will think the west is the west wall, or the west corner of the classroom, or the west side of their playground. This tendency to limit the west can be checked if sometimes when the children are pointing to the west an imaginary western journey is taken. The real meaning of west is then more apparent, thus:

We are going to take a long flight westwards to see what we shall find. We will travel with the aid of the globe and the flat map of the world. We start from the east coast of England, say the town of Hull. We cross England and the mountains of Wales. Then we fly still westwards over a narrow sea to Ireland. Crossing Ireland, we soon come to the sea again, a great ocean this time, the Atlantic Ocean. On the other side of the Atlantic is North America, a piece of land so big that it is called a *continent*. Westwards we go across North America (the land of the Canadians and Americans, and once the Red Indians) until we come to the sea again—an ocean even larger than the Atlantic —the great Pacific Ocean. If we fly westwards over this ocean, we reach the lands where the Japanese and Chinese live, part of the continent of Asia. Flying westwards across Asia, we reach Europe, because the two continents are joined. Then we cross a narrow sea, and find ourselves on the *east* coast of England again. We have flown around the world. We can reach countries that we say are in the Far East, like Japan and China, just as well by going west as by going east, because the world is round.

Let children, with the help of a map, tell about a journey westwards. Let them take a flight eastwards and write down the names of the seas and coun-

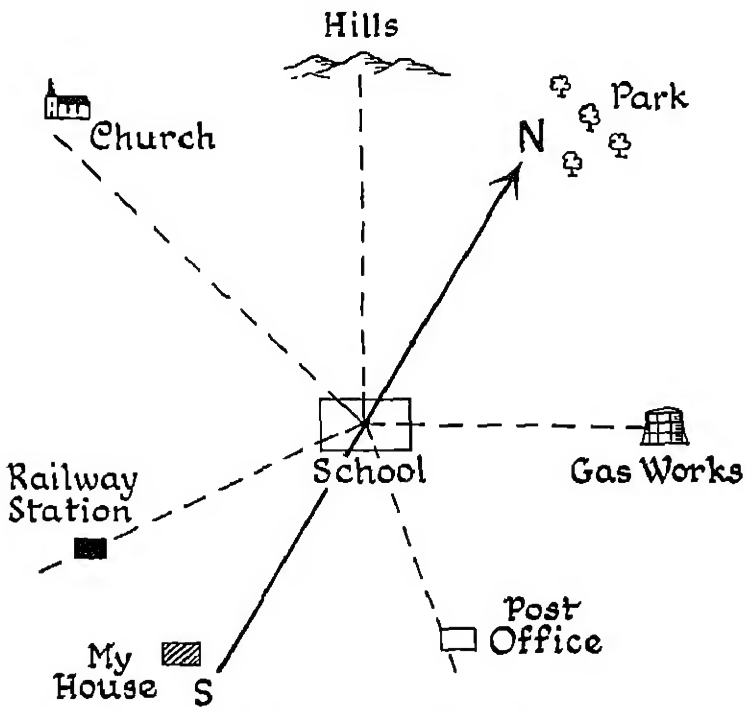


Fig. 21.—Chart to show Direction of Places round the School.

detailed descriptions of the countries passed but to get the children familiar with the arrangement of the great land and water masses.

At no time will home geography be kept in a watertight compartment, but it must always lead the children to think of lands beyond the home. The first map and the study of maps will begin in connection with home geography and the child's environment. Maps are dealt with in the next chapter.

ties passed. Later, more flights or journeys may be made eastwards and westwards, not for the sake of giving

CHAPTER THREE

SIMPLE MAP-MAKING AND MAP-READING

THE making of simple sketch-maps, and the reading and using of maps, is perhaps the most important part of the geography syllabus. Much of the geography learnt at school may be forgotten, but the child who has learnt to understand and read maps, and also how and where to get information, can, when he leaves school, always keep his knowledge up to date. Map work, too, is of great importance because it is the chief kind of geography that will be really needed after schooldays. In the first and second years children will learn how to read and draw simple maps of the way to school, the way about the town, the village, or the countryside, together with maps of the school, the school playground, and surroundings. They will also begin to learn how to use the globe and their atlas maps (see coming chapters). This work continues in the third and fourth years, with more about the use of scales, and from these simple beginnings they pass to the maps of the Ordnance Survey (see Chapter V).

There is no need in the geography lessons to confuse children by first teaching them *plans*, and then maps. A plan is only a special sort of map. Plans are also dealt with in the arithmetic lesson.

Many young children have the map sense, and in their lessons on direction they naturally begin to draw maps. A child when describing his walk to school often makes a rough drawing. He says "I live here. I walk along my street for a short way. Then I turn down a road where I see a pillar-box." (He draws his home, street, and a ring for a pillar-box. He can be told to put P.B. beside it.) "I go a long way down this road." (He makes this road much longer than his street, thus unconsciously using a scale.) "I pass many shops. Then I turn down by a church and soon reach the school." A drawing, such as that shown in Fig. 22, will result. Sometimes the teacher draws the map on the board as the child explains the way he comes. Often the child has to be reminded that he must say whether he turns to the right or the left.

Children are much interested if the teacher draws on the board his way to school, or part of his way. From watching his drawing they get many ideas for drawing their own rough maps.

Fig. 23 is a useful sketch-map to draw on the board for the children to copy. They will learn many things from it. They can fill up the open spaces with what they like—trees (the teacher shows them how to draw trees on a map), grass, a row of shops, a pillar-box, etc. Let them notice the direction arrow. Why is it important? Under-

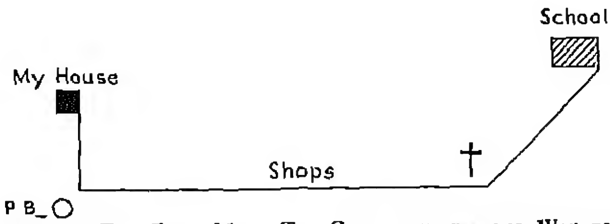


Fig 22.—The First Map. The Child explains his Way to School.

takes them about a quarter of an hour. With this rough guide they will enjoy finding the distance of different places from their school and home. This will be a great help to map-making.

The following are some graduated suggestions for map work:

Maps to illustrate Stories

Children much enjoy seeing stories illustrated by a map, or trying themselves to draw a map for a story. The story of Red Riding Hood is a good story for this purpose. Three cottages have to go on the map—Red Riding Hood's, the Grandmother's, and the Wood Cutter's. Then there are the woods Red Riding Hood went through. The wandering path as she picked flowers must be shown, and the short cut of the wolf through the woods to the Grandmother's cottage.

Fig. 24 shows a map for the story of Snow White and Rose Red. The children will hear or read this story in the literature lesson (see Volume I, English) First the cottage is drawn with the two rose trees by it. Then woods are drawn. The children can be shown on the board how to draw fir trees and other trees. Then paths have to be drawn through the woods, one to where Snow White and Rose Red picked up

neath they write the caption, "A house facing north-west." How do we know that the house is facing north-west? In which direction does the back of the house face? In which direction do the sides face? The direction arrow and their compass-cards will help them to answer these questions. It helps some children if a west–east line is drawn across the north–south line.

The children also write under their maps the directions of the four roads. Let the children draw many rough sketch-maps to show (1) their house and street, and roads branching from their street, something like Fig. 23; (2) their way to school; (3) their way from home to the shops when they shop for mother; (4) the way from home to a railway station or pillar-box, etc.; (5) a map of a lonely island where a treasure is buried, or some imaginary place. In all these rough drawings the children should show where north is, and write *a title under each.* A good many rough maps of home surroundings, the park, school playground, etc., make the children familiar with the map idea, and are of more value *at first* than elaborate scale drawings.

Help the children to get some idea of the length of a mile as soon as possible. Tell them of some convenient place just a mile from the school. Let them walk this distance and find out how long it takes. They may find it

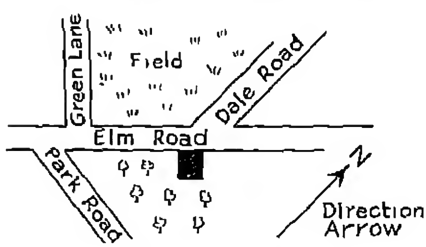


Fig. 23.—A House facing North-west.

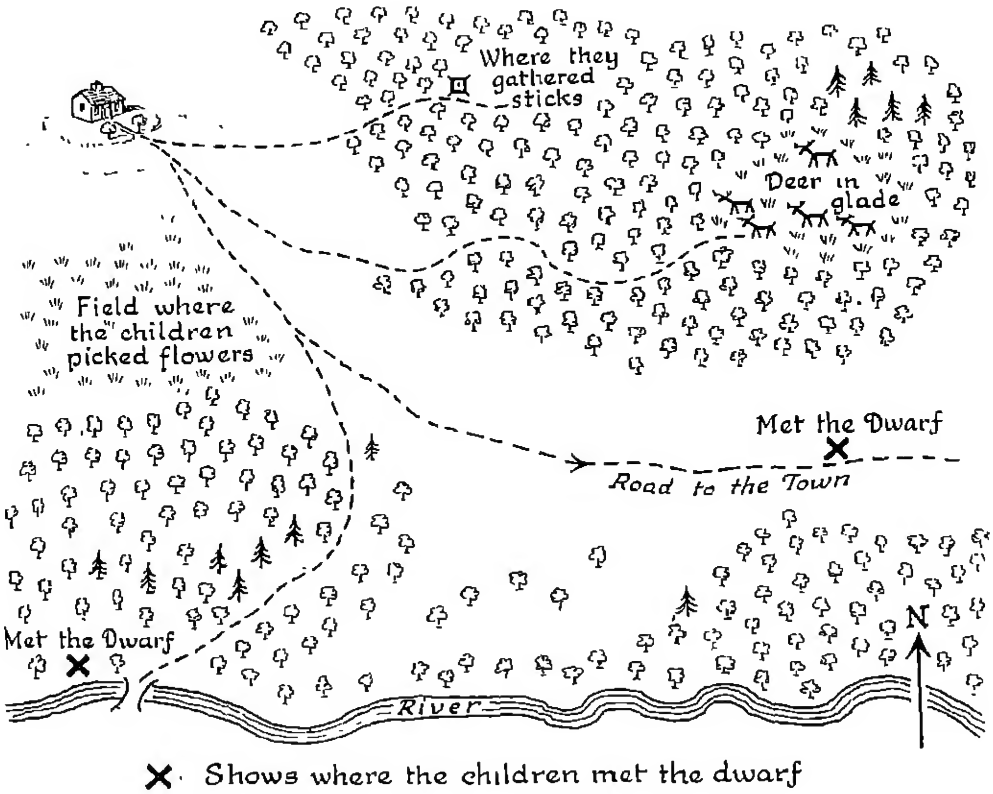


Fig 24.—Map for Story of Snow White and Rose Red.

sticks, one through the woods to an open glade where they watched the deer, one to the river where they waded and fished. The winding river must be shown, also the road to town, and fields where the children picked flowers. Crosses are put at the places where Snow White and Rose Red met the dwarf. The map often explains words and ideas in the story, and encourages careful listening.

Many other stories that children know can be retold with the help of maps, also stories invented by the children. Through these maps they realize the necessity for symbols rather than *pictures* or *plans* for many of the objects and features to be put on the map, a cross, for example, is a symbol of a church. A cross is easier and smaller to put on a map than a plan or picture, and there is no doubt what it stands for.

Drawing these rough maps also prepares the way for scale drawing. The children draw *short* or *long* paths or roads. The idea of representation in a different size comes natural to children, so does the use of symbols, for most of the early drawings of young children are symbolical.

Maps of the Schoolroom or Rooms at Home

Again these maps need only be approximations to scale. The children

are told to draw a map of their classroom *to show where they sit*. Every map will thus show something different from the other maps. First they draw the shape of the room, oblong or square, etc. Here they may need help. The teacher gives assistance on the blackboard *whenever needed*. The finished maps are taken home to show their parents exactly where they sit; the maps are also used for exercises; for example, "Show by a dotted line your path from your seat to the door or cupboard." "Show the shortest or longest way from a certain seat to the door." The direction arrow is, of course, most important, and children can be asked questions on this.

When the map of the classroom has been thoroughly understood, a map of the school may be attempted. This will only be in very general outline; any attempts at details are a waste of time.

Now is a good time for the teacher to show the class a large map of the school or one floor or storey of the school. Again be sure there is an arrow pointing north, both because children must get into the habit of showing north on their maps, and because more questions and exercises are possible. Many questions and practical problems can be set on this map: Where is the sunniest room? Is there a room that never gets the sun? Find your room. Whose room is this? Which is the quickest way into the street from your room? Show where a visitor enters and how he gets to the head teacher's room, and so on. One must be careful not to overdo the questions, especially with bright children. When once children understand the map, it is waste of time letting them answer questions which are too obvious.

The School Playground, and Streets, etc., around the School

It is very important that the children should learn "how to *set* the map" correctly on the playground—with north on the map pointing north. They should learn, too, how to set the map if the north point is neither given nor known. This is of great importance in working with maps out of doors. Some outstanding building, etc., can be used to set one's map by.

Encourage the children to make little maps of their gardens, or part of a park they know. An interesting map is a tree map, showing where different trees are. This can be done in connection with nature study. They will also draw rooms at home, or a whole floor, or a passage with rooms leading from it, etc. They will now begin to think of scale as something necessary and accurate.

Drawing Maps to Scale (see also Arithmetic Section)

Because of their rough, often freehand maps, the children begin to see the need for drawing to scale. With a knowledge of the linear table they will acquire the desire to measure either approximately by stepping or accurately by standard measures. They realize that large and small, long or short are vague terms. Where accuracy is necessary, a scale is essential.

A Room drawn to Scale (Fig. 25)

Draw on the board for the children a very simple map of a room drawn to scale (Fig. 25). The lines drawn across are a help at first. The children copy it, noting the walls are four inches one way, and three inches the other. The outline must be drawn first. They

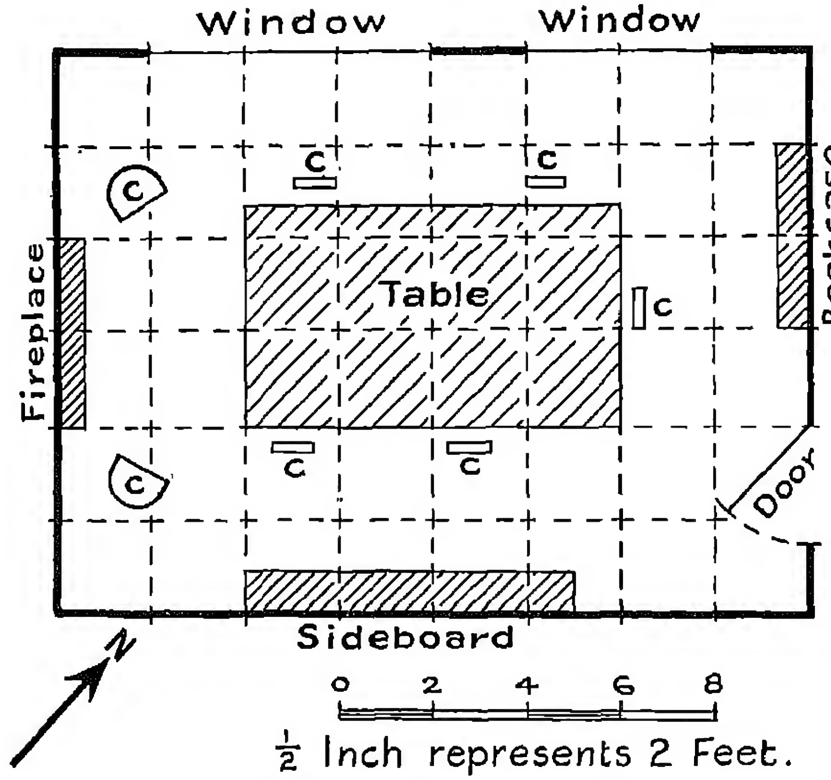


Fig. 25.—Map of Dining-room drawn to Scale

notice how the windows, doors, etc., are shown.

When they have studied and talked about the details they put them in. They notice especially the scale which says that ½ inch on the map represents 2 feet. Remind them that unless a scale is given one cannot tell the size of things shown on a map. With a scale one is able to make an object *uniformly* small, that is, the right *shape* but smaller.

Many useful questions can be set on Fig. 25. Measure the room from wall to wall. The longest measurement is the *length* of the room, the shortest is the *breadth* or *width*. How long is the room in feet? How wide is the room in feet? How long is the table in feet? How wide is it in feet? etc., etc. The children draw a map of the classroom to scale, or a room at home. They will have plenty of practice in drawing to scale in the arithmetic lessons. Remind them that they must first make an outline to show the walls of the room; for this two measurements are necessary: (1) the width of the room in feet; (2) the length of the room in feet. Having found these measurements, they decide on a scale. When the scale is settled, the walls are drawn, and windows and door added. The windows are open spaces in the wall, so faint lines are drawn for these, and thick lines or double lines for the walls. Then they put in the desks, cupboards, etc.

All large things are drawn to scale, but not small ones, such as chairs, because everyone knows the size of ordinary chairs. They show the position of the desks and where the teacher sits. When children are measuring the length of the classroom or any large room, etc., a yard measure is useful. Failing this, they can cut a piece of string three or four feet long with the help of their ruler, or mark three feet on a piece of string with coloured thread.

Maps of the Playground, Gardens, etc. The Length of One's Stride

A useful measurement for children to know when making maps of large places like the playground is the length of their ordinary *stride*. It needs, however, some trouble for a child to find out just how wide his usual stride is. One way to find out is to get a long piece of cord and measure it carefully. A piece 10 feet long is a useful length. This cord is used to measure a distance of 50 yards in the playground. This distance is clearly marked on the ground. The child paces over this distance a number of times, trying to walk in his usual way. Each time he writes down the number of paces or strides made. The number may vary slightly, but the average number of paces taken to cover the fifty yards can be found. When a child has found the average length of his stride, it may interest him to write down the number of feet he covers when he walks (1) 50 paces, (2) 100 paces, (3) 250 paces.

Another quicker way to find the length of a stride: from some given mark, take twenty ordinary strides, measure the distance walked and divide this distance by twenty. The result gives roughly the length of a stride.

The children measure the length of each wall or boundary of the playground. If necessary, one child can be "the measurer." Rough maps are drawn and the measurements put on. Then a good scale is thought out, and the maps drawn properly. Children can make maps in this way of part of the Park, etc.

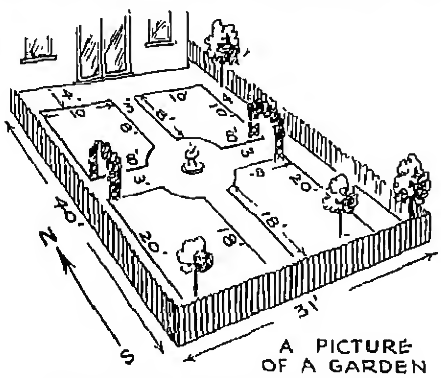


Fig. 26.—Bird's-eye View of Garden.

Making a Map from a Picture (Fig. 26)

It is often useful to let the children draw maps from pictures. Fig. 26 is a picture of a garden, but the measurements of all important parts have been put on it so that a map of the garden can easily be drawn. The children notice all the details, paths, grass plots, arches, bird-bath, trees. The chief measurements are put on the board so that the children can see them easily and think out their scale; for example, a scale of $\frac{1}{4}$ inch to 2 feet. They get the outline of the garden drawn first. Then they put in the paths and the grass plots according to the measurements given. Lastly, they add the small details. Children who have gardens at home make pictures of them. Then they pace their gardens and put the measurements on their drawings. Then a map is made. It is interesting to let

the children draw a map of a garden they would like to have, or how they would like to arrange their own gardens.

COMMON SIGNS USED ON MAPS (Plate I)

As children draw more maps, they become alive to the need of more symbols. As soon as they need them, they should be shown some of the common signs used by map-makers. Plate I may be pinned up at appropriate times for the children to study or look at if they need symbols. They see the necessity for drawing such things as railways, stations, bridges, etc., so that they do not take up too much room. Remind the children that they can make up signs or symbols for themselves if necessary, but it is much more useful if everybody as far as possible uses the same signs so that maps can be read by all. The children will see that the signs on Plate I are common-sense ones. See if any child can tell why a church with a tower is shown by a cross on a square, and a church with a spire by a cross on a circle. (A tower is square, a spire round, or almost round—eight-sided.) A cross does generally for a church. The children like to copy these signs in a self-help booklet about map-making. Then they can consult it for themselves when they like. In these booklets they can write all the useful facts that help them to draw maps—the length of their stride, specimen maps, and so on. Children will probably bring much information to school from their fathers' road maps. Draw some maps on the board to see if they can use the signs, and set them questions on maps, like those which follow about Plate II. These questions can be set for individual work. Make sure they understand the scale—" 1 inch represents 200 yards," or, more shortly, " 1″ to 200 yards," or " 1″ : 200 yds."

TYPICAL QUESTIONS on Plate II

(1) St. Mark's Church has a tower. Find it and describe its position. (2) Name a road that runs roughly from N.W. to S.E. Name a road that runs from E. to W. In which direction does the railway run? (3) What is the north bank of the river like between the two bridges? What is the south bank like? (4) If you stand on the railway bridge, in which direction would you look to find a church with a spire? a church with a tower? (5) Describe how to reach the post and telegraph office from the school. (6) How far is it from the station to Pine Road, and from the school to Ash Road? (7) Where do the footpaths on the map lead? (8) How long is the river from the railway bridge to the road bridge? Use a piece of cotton to find the length. Then measure the piece of cotton with your ruler, and consult the scale. (9) How would you go from the boat-house to the telegraph office? (10) Describe the view from a top window on the north side of a house in Wood Road.

COLOURING MAPS

Children always want to colour their maps, and of course tend to overdo the colouring. Help them to see that a few colours make things stand out clearly and are effective, but too many colours hinder each other and are unnecessary. Blue is the most useful colour. It is used for the sea, lakes, ponds, and rivers if they are broad enough. Black is always used for railways, roads may be brown. In some cases fields may be coloured green to show grass, and yellow for corn, and brown for

ploughed fields. But it is better not to encourage this kind of colouring, as it may confuse the children when they study relief maps, where *green* always means *low land*, even if it is sandy barren land. Remind the children that they must put a key by the side of their map to tell what the colours and signs mean, especially if they are not well known. Everyone knows that blue means the sea, but brown need not be ploughed fields; it is more often high land (see Chapter V). To gratify their love of colour, the oblongs and squares for houses, instead of being shaded grey or black, may be painted red.

Maps and Home Geography; Map Book of my Walks

Children will like to draw maps of the places around their school and home for a "Home Geography Map Book" or "Map Book of my Walks"; for example:

(1) A map of one of the principal streets. The child walks along one of the streets and notices (or makes notes of) all the important shops he is going to show on his map. All shops need not be named, but large shops, a cinema or library, etc., should have larger squares drawn for them, and appropriate letters printed on or by each, as C for cinema. If initials are confusing, different signs can be thought of, especially for shops—a milk-bottle for a dairy, a small red bell for a fire station, a star for a cinema, and so on. The pupil paces the street to get the buildings the right distance apart. He walks in his usual way counting his strides. If there are special places for crossing the road, these should be marked on the map. The children must be warned that they can pace the length of streets or roads they walk along, but they must *never pace the width of a road.* They can see for themselves that this is not necessary.

Children who live in or near the country can draw interesting maps of a walk in the country. In connection

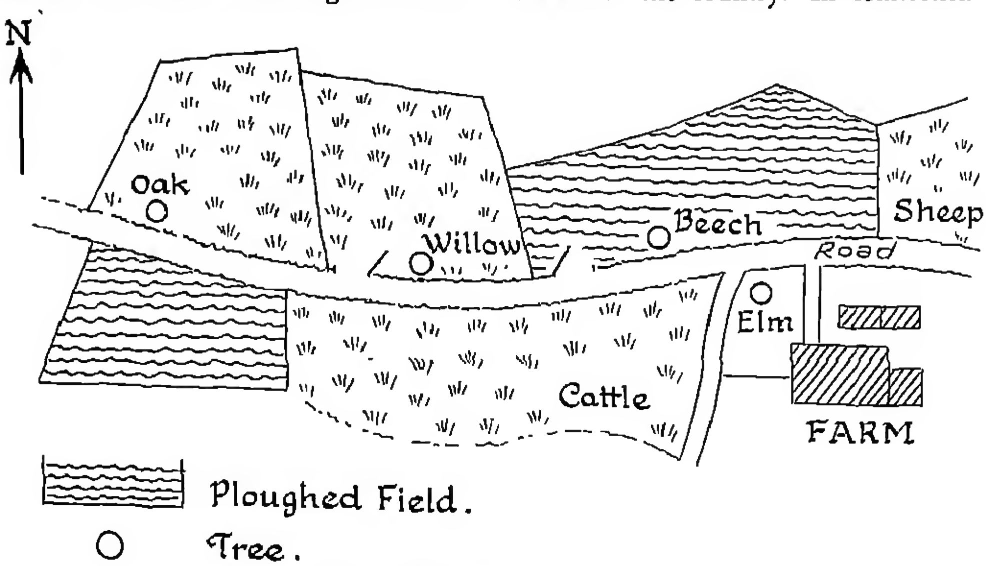


Fig. 27.—Map of a Country Walk.

with nature study they show where they picked certain flowers or saw a bird's nest, etc. They draw the roads as carefully as possible, and the fields on each side, and how they are used, gates, big trees, etc., as in Fig. 27. They make rough sketches as they walk along trying to get the correct shapes of the fields on each side, and putting a letter to show how each field is used. When they are back in school they can make a neat copy of their map and add any colours that are necessary. It is interesting to make a map of the lane in winter and summer. In summer they can find out what is growing in each ploughed field.

They will probably need long pieces of paper for some of their walks. These can be folded and one edge pasted in their books. They like the idea of making *folded maps.* The children must be constantly reminded to put in their direction arrows, a key to the signs, a scale if needed; for example, $\frac{1}{4}''$ to 1 stride or pace (pace about 2 feet), and *above all a title* or the purpose of the map. In the arithmetic lessons (see Arithmetic Section) the children will get much practice in simple scale-drawing, and working little problems in scale-drawing.

From the maps suggested above it is an easy stage to the first Ordnance map. In the third and fourth years the children will begin the first study of Ordnance maps. The stages covered are roughly (1) Picture-maps and sketch-maps; (2) maps of classroom, school, etc., drawn to scale. Maps of park, walks, etc., etc.; (3) Ordnance Survey map—the largest scale, called the 50-in. map (scale 50 ins. to 1 mile); (4) the 25-inch Ordnance Map (scale 25 ins. to 1 mile); (5) the 6-inch Ordnance Map (scale 6 ins. to 1 mile).

For Ordnance maps and more advanced map work see Chapter V.

CHAPTER FOUR

DIRECTION AGAIN

Direction again—the Sun

IN their simple science lessons the children will have learnt about the sun, the journey of the earth round the sun, and its rotation on its axis—day and night (see Volume IV, NATURE STUDY AND SIMPLE SCIENCE). The terms *axis, North* and *South Pole, Equator* have also been introduced.

Remind the children about what they have learnt from their shadow-sticks. When the sun's arch in the sky is low, the shadows are long. When the sun's arch is high, the shadows are short. Short shadows mean the sun is high and it is hot, while long shadows mean the sun is low and it is cooler.

Remind them of the word *horizon*. Whenever they are out of doors and can see the horizon, they should point towards it and notice the position of their arm. It is *horizontal*. In Fig. 28, Mr. H. in any part of the world is pointing straight in front to the horizon. His arm is *horizontal*. In Fig. 29 Mr. S. in London is pointing to the sun at noon on December 22. The sun's arch is lowest about this date, midwinter, so Mr. S. has not to raise his arm far. In winter in Britain the sun is low, the shadows long, and the days cold. In which direction is Mr. S. pointing? In Fig. 30 the same Mr. S. in London is pointing to the noonday sun on June 21. The sun is much higher, so he has to raise his arm higher. The sun is at its *highest* in Britain at noon about June 21. (More about the sun in summer and winter and the altitude of the sun, etc., will be found in NATURE STUDY AND SIMPLE SCIENCE, Volume IV.) The exact dates for the sun at its lowest and highest do not vary more than a day from the dates given above. There is no necessity for the children to point to the sun. The stick-figures are drawn to show them exactly the altitude or height of the sun in summer and winter. The dotted line shows the horizon. In midwinter the arm is raised 15°, and in midsummer 62°.

In Fig. 31, Mr. V., who lives in Africa near the Equator, is pointing to the sun at noon on March 21. He has to point straight up above his head, because the sun is exactly overhead. His arm is *vertical*. Mr. S.'s arm in Figs. 29 and 30 is slanting. At the Equator the noonday sun, even when it is not actually overhead, is always higher than it is in Britain. So in this part of the world it is always very warm all the year round. There are therefore no seasons, only sunshine and rain, and sometimes more rain than at others, but always some sunshine.

Some children may want to know why when the sun is high, its heating power is greater. Only if they ask, should the explanation be given. Fig. 32 shows the greatest difference in the slant of the sun's rays in England. Each beam of sunlight at midday has

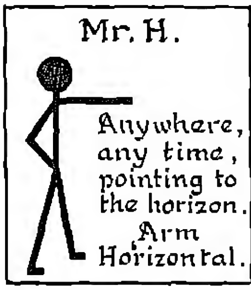


Fig 28

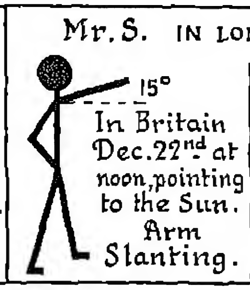


Fig. 29.

Fig. 30.

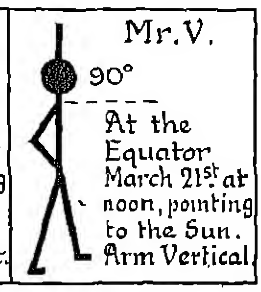


Fig. 31.

to warm more than three times as much flat ground in midwinter as midsummer. But the air stops some of the sun's heat on its way to the earth, so there is a further serious loss of heat in winter. If we travelled south, however, the sun would rise higher in the sky as we approached the Equator, and at the Equator we should find the weather always hot (at least at sea-level), and summer and winter would have no meaning.

The children look at the school globe to find the position of the British Isles in the Northern Hemisphere and the position of the Equator, so that they know where Mr. S. and Mr. V. stood. They look at Fig. 10 again. They make a drawing of Fig. 10 and write under: "As a rule the nearer a place is to the Equator the warmer it is; and the nearer a place is to the North Pole or South Pole the colder it is." They draw the four stick-figures in their direction books, and write notes in under each. This helps them to understand what is meant by the *height* or altitude of the sun at various times of the year. These drawings also help them to understand the important words *horizontal* and *vertical*. These need to be taught over and over again from different points of view before they become a part of a child's thinking vocabulary. A certain amount of overlapping (provided the approach is different) in geography, nature study, simple science, and arithmetic is of value.

The children add drawings of *hori-*

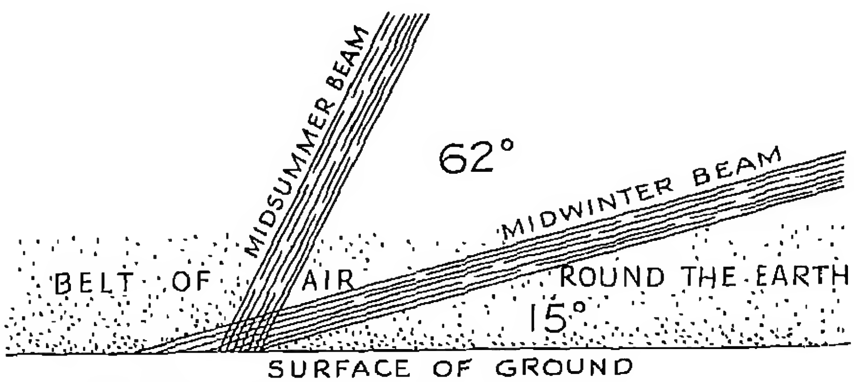


Fig 32.—The Sun's Rays in Summer and Winter at Midday.

zontal and *vertical* lines to their picture dictionaries.

The children should have thoughtful questions like the following to answer:

(1) If we live in the Northern Hemisphere and look towards the Equator, in which direction are we looking?

(2) If we live in the Southern Hemisphere (New Zealand), in what direction do we look if we wish to face the Equator?

(3) In which month in Britain is the sun lowest at noon? In which month is it highest at noon?

(4) When are noon shadows shortest? When are they longest?

(5) In what part of the world is the sun sometimes directly over one's head at noon so that one has to put one's arm in a vertical position to point to it?

The North-South Line again; the Prime Meridian

The children look at their north–south line on the school playground. If possible, let them extend this line as far as possible both ways. Tell them this line is called a *meridian*. It is the meridian of the school. *Meridian* means the middle of the day, or midday; an exact north–south line can only be found at midday when the sun is highest in the sky. It is sometimes called a sun-line because it is drawn with the help of the sun. If this line could be carried farther and farther north, it would reach the North Pole. If it were carried farther and farther south, it would cross the Equator and reach the South Pole (Fig. 33). If a piece of string could be stretched round the earth itself from Pole to Pole and passing through the playground, it would lie on the north–south line there and look just like it.

Let the children look at the school globe and the map of the world for the Equator and for meridians. They look especially for the Greenwich Meridian (London) on the map of the world and England and Wales. The Greenwich Meridian runs from the North Pole to the South Pole, passing through Greenwich Observatory on the way. Outside the Observatory its course is shown by a line cut in a piece of stone. This is more permanent than a painted line on the ground. The words "Greenwich Meridian" are carved beside it. On maps and globes this meridian is marked 0 because the distances of the other meridians are measured from it; for this reason the Greenwich Meridian is called the Prime Meridian or First Meridian. There are no buildings, signposts, or roads at sea to show sailors the way, but by means of these two lines—the *Equator* and the *Greenwich Meridian*—drawn at right angles to each other, sailors can describe their position at sea; and the position of every place in the world can be described by reference to these two lines. The children will learn more about them later, especially when they are learning to use the index of their atlas in the third and fourth years. At first they should remember the two lines shown in Fig. 33. The distance of a place from the Prime Meridian is called its *longitude*. The distance of a place from the Equator is called its *latitude*.

The children in the upper classes can read more about meridians in *Projects for the Junior School*, Book IV, Chapter VII (Harrap). There they will learn how sailors can find their *latitude*, their distance from the Equator, by the Pole Star, and their *longitude*, their distance from the Prime Meridian,

Fig. 33.—Two Useful Lines on the Globe. The Equator and the Prime Meridian or Greenwich Meridian.

by the clock. Children interested in clocks (see History and Nature Study and Simple Science, Vols. II and IV) will like to hear about the sailor's clock, the *chronometer* in *Projects for the Junior School*, Book IV (Harrap).

It is a great help for future work if the children get familiar with these two lines on the school globe and atlas—the Greenwich Meridian and the Equator.

Lessons must be given frequently on the globe and map These will fit in with both regional and world geography as well as with a more detailed study of the British Isles in the fourth year. At the end of the Primary School course a pupil should be able to understand the significance of every mark and colouring on a simple map, and be able to use the index intelligently.

Further Study of the Globe

More Useful Lines on the Globe and Map (Fig. 34)

When the children know the Equator, the Poles, the Northern and Southern Hemispheres, and the Greenwich Meridian, teach them four other lines that have something to do with the sun, and may be called sun-lines. These lines also teach some useful words. They are shown in Fig. 34 The children should find them on the school globe and the atlas map of the world, and any map they are studying. Two lines are in the Northern Hemisphere; these are, the Tropic of Cancer and the Arctic Circle. Two are in the Southern Hemisphere; these are, the Tropic of Capricorn and the Antarctic Circle.

These four sun-lines divide the globe

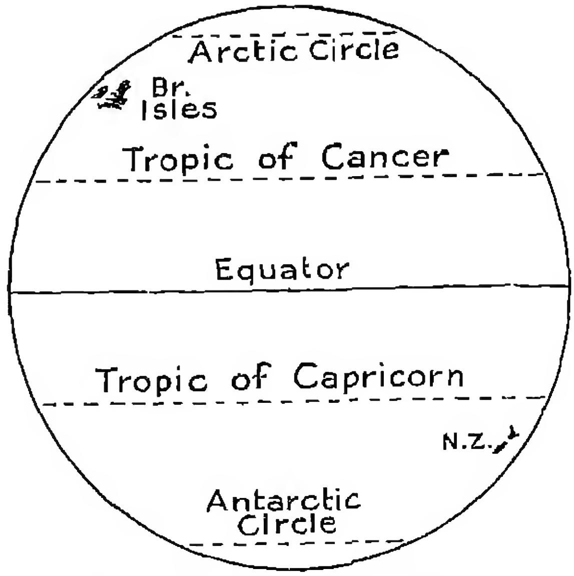


Fig. 34.—Five Useful Lines or Sun-lines

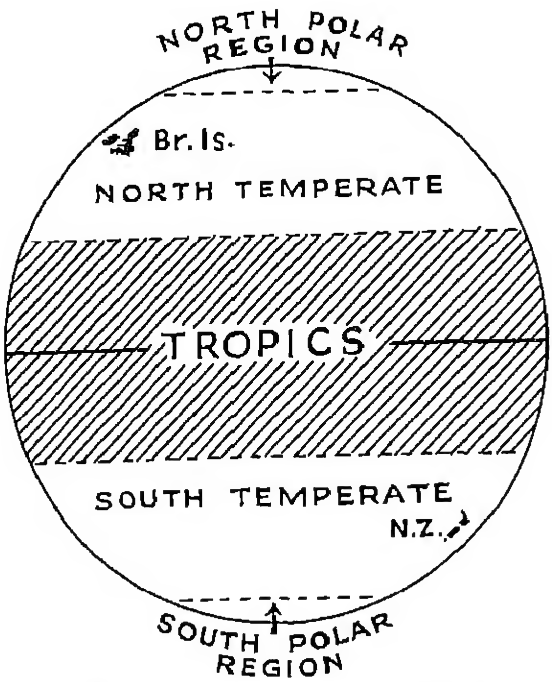


Fig. 35.—Five Belts or Zones or Regions.

into *five strips*, or *belts*, or *zones* (Fig. 35). Since the heat we receive from the sun grows more from the poles to the Equator, we know the hottest strip will be in the middle, the *Hot Belt*, the wide belt with the Equator crossing it. This hot belt is called the *Tropics*. (It used to be called the Torrid Zone—torrid means hot.) Point out that this is a good name because it is bounded by the Tropic of Cancer on the north, and the Tropic of Capricorn on the south. In the *Tropics* are the places that have the sun high in the sky, and *directly overhead* at some time during the year. There are two *Cold Belts*; these are not really belts or strips, but caps with the North Pole in the centre of one, and the South Pole in the centre of the other (Fig. 35.) These Cold Belts are generally called the Polar Regions, the *North Polar Region* and the South Polar Region. They used to be called the North Frigid Zone and the South Frigid Zone. Few children will know that *frigid* means cold. It is a useful word, and easily remembered if connected with *frozen*. The North Polar Region is inside the Arctic Circle, and the South Polar Region is inside the Antarctic Circle.

Now show the children the two *Cool Belts* or *Temperate Zones*. It might be explained to the children that *temperate* means moderate, not extremely hot and not extremely cold. The North Temperate Zone in the Northern Hemisphere is where we live. It lies between the Tropics and the North Polar Region. The South Temperate Zone, where New Zealand and Australia are, lie between the Tropics and the South Polar Region. Make it clear to the children that as the temperate zones stretch from the very hot lands to the cold lands, they vary much in different parts. The children will probably be able to say which part of the temperate zones are very warm, and which parts are cold. Let them notice the position of the British Isles and New Zealand. The British Isles are nearer to the Polar Regions than the Tropics, so they never suffer from very great heat. Because the climate in the temperate zones varies so much, a further division is often made and we talk about the "warm temperate zone" and the "cool temperate zone." Britain, for example, may be said to be in the cool temperate zone, while Egypt and

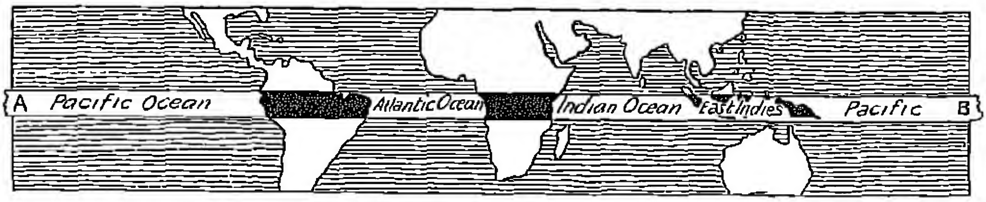


Fig. 36.—LANDS THROUGH WHICH THE EQUATOR PASSES.

Palestine are in the warm temperate zone. Places in the temperate zones that are very near the Tropics are said to be sub-tropical; for example, the Sahara.

The children make booklets about the globe in which they write all they learn about it. These books will grow as their knowledge grows. They copy Figs. 33, 34, and 35 in these books.

They can make their booklets more interesting by finding the names of animals and creatures characteristic of each belt:

North Polar Region: polar bear, seal, reindeer, Arctic fox, etc.

North Temperate Zone: wolf, bear, deer, cattle, etc.

Tropics: elephant, tiger, lion, monkey, giraffe, etc.

South Temperate Zone: kangaroos, emu, koala bear, dingo, etc.

South Polar Region: penguins.

Round the World with the Equator (Fig. 36)

The following is an interesting way of further exploring the globe and learning about it.

(1) Let the children follow the Equator round the globe or across the flat map of the world thus:

Begin in the middle of the Pacific Ocean, for example at the meridian 165 degrees. Notice where the meridian crosses the Equator. Having found this point, begin to trace the Equator eastwards with the finger. The line crosses the Pacific to South America, crosses South America and the Atlantic Ocean to Africa. It passes almost through the middle of Africa. Then comes the Indian Ocean and a group of islands called the East Indies. To the north, but not touching the Equator, is Asia. After passing the East Indies, we reach the Pacific Ocean and are soon back to our starting-point again. We have followed the line of the Equator round the world. What countries have been crossed?

(2) Take a narrow strip of paper, say $\frac{1}{2}$ inch broad or $\frac{1}{4}$ inch broad, just long enough to go round the globe (or right across the flat atlas map of the world). Place this over the Equator, or if it is easier with one edge touching the Equator as in Fig. 36. On this mark the continents and oceans through which the Equator passes (AB, Fig. 36). Shade the land grey on the strip and leave the sea white or colour it blue. Looking at your strip, you can see at once where the hottest parts of the world are—in South America, Africa, and the East Indies. This exercise is most valuable if the children use a globe When the strip is taken from the globe and stretched out to make a straight line, it looks like A–B, Fig. 36.

If the children place the strip across the middle of a large sheet of paper, two marks will show where Africa must be fixed, and two marks show where

South America should go, and so on. Thus they have the beginning of a flat map of the world. Whenever possible the globe and the flat map of the world should be compared.

Further Exercises on the Globe

(1) Make a ball of Plasticine. Push a knitting-needle through the middle. Spin the ball the way the earth spins. Where do the poles come? Mark the Equator.

(2) Which continents are (*a*) completely in the Northern Hemisphere, (*b*) completely in the Southern Hemisphere, (*c*) cut by the Equator?

(3) Find out from the globe or flat atlas map the continents that are cut by: the Arctic Circle, the Antarctic Circle, the Tropic of Cancer, the Tropic of Capricorn.

(4) What are the boundaries of the North Temperate Zone?

(5) Write the names of the six continents—Europe, Asia, Africa, North America, South America, Australia and New Zealand. By the side of each say in which belt or belts it lies.

(6) Finish these sentences with the help of your map: Australia is cut by . . . . ; Asia is cut by . . . . ; Europe is cut by . . . . ; Africa is cut by . . . . ; North America is cut by . . . . ; South America is cut by . . . .

(7) Into which parts are the temperate zones sometimes divided?

(8) Which continents lie partly in the Southern Hemisphere and partly in the Northern Hemisphere?

(9) Which zones are in the Southern Hemisphere? In the Northern Hemisphere?

(10) Make drawings of Fig. 34 to show the sun-lines, and write their names, and of Fig. 35 to show the zones. Write their names in clearly. Add these drawings to your book about the Globe.

There is a most useful map of the world in W. and A. K. Johnston's *School Atlas of Great Britain and Ireland,* which shows very clearly the Cold Lands, Cool and Warm Lands, and Hot Lands. It is useful for the children to use when considering the above questions or other questions set by the teacher, such as: Which continent has most land in the Tropics? Which continent has most cool or temperate land? They can see clearly the position of the British Isles with regard to the other countries. They can see how much farther the British Isles are from the Tropics than New Zealand is; therefore New Zealand must be warmer than the British Isles.

CHAPTER FIVE

PRACTICAL HOME GEOGRAPHY

Finding out Facts about Hills

IN almost every neighbourhood there are hills, although some may not be very high. Let the children find hills in their neighbourhood, and tell what they know about them. Draw a sketch of a hill on the board to teach the words *slope, summit, base* or *foot, height,* as in Fig. 37.

Explain to the children that if a man were to walk up this hill, going from base to summit, he would walk more than a mile; but this does not mean that the hill is a mile high. The children can prove this for themselves (Fig. 38). Place a plank (say 11 feet long) with one end resting on the ground and the other on a box four feet high. If a child starts from the end and walks nearly to the upper end, he will walk about nine feet, but he is only four feet above the ground. The height of a hill is much less than the length of its slope.

Suggestions for work out of doors and in: (1) Find some ground near your home that seems nearly level. How can you find out if it is really level? (2) Where is the longest slope in your neighbourhood? The steepest one? (3) Watch the water carrying off soil after rain. Where does it go? (4) Where is your highest hill? (5) On which part of a hill is it coolest, the bottom or top? How could you prove it? (6) Why are hills likely to be dry? (7) Why were castles often built on hills? (see Norman Castles, HISTORY, Volume II). (8) In which season of the year is it especially pleasant to be on a hill? Why? (9) Where is your most beautiful view? (10) Tell about any hills you have climbed.

The above work will vary according to the locality of the school—the flat land of East Anglia, the mountainous land of Wales, and so on. In Wales children will know it is colder on hilltops than in valleys, because they will have seen snow on the mountain tops when it is raining in the low lands near by. But wherever the children are, there are sure to be slopes and very low hills. To find these encourages observation. Children enjoy thinking out all the advantages and disadvantages of living on a hill. Advantages: dry, cool, fine view, etc. They make interesting self-help booklets about Hills, in which they put drawings to show the different parts of a hill (Figs. 37 and 38), and lists of all the facts they have learnt or discovered about hills, such as that it is colder at the crest of a hill than at its foot, the height of a hill is much less than the length of its slope, the rain runs off hills, etc. They tell about hills they know, and walks uphill, etc.

Highlands and Lowlands on Maps

Through exploring the hills in their neighbourhood and trying to draw them, the children want to know how hills or high land are shown on maps.

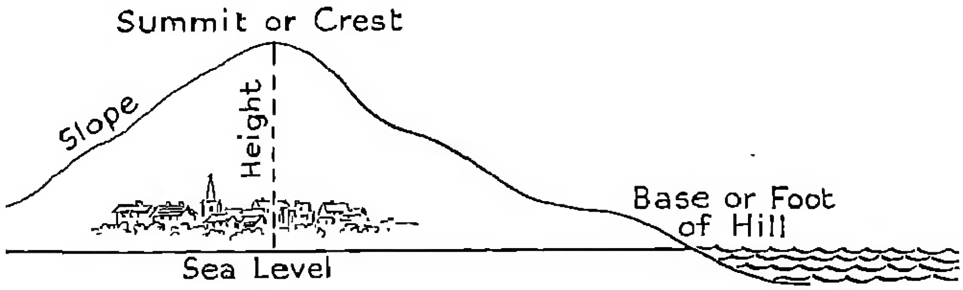


Fig 37.—A Hill and its Different Parts.

On their picture maps and rough maps children will probably draw them as they were drawn long ago by explorers and pirates (Fig. 39). A few children may have seen the plan of Treasure Island in Robert Louis Stevenson's story. But drawing hills or mountains scattered about as in Fig. 39 would not do for accurate maps. They take up too much room, and they do not show how high they are, or how high the country round the hills is.

On many maps the highest point is often shown by a dot, and by the dot the height is put in feet, as in Fig. 40. In this map we know the hotel is built on the highest part, and roads from the hotel must slope downwards.

All heights are measured from the sea or "*sea-level*" (Fig. 37). The hotel in Fig. 40 is 260 feet above sea-level. These heights are called "spot heights." By means of an Ordnance Survey Map the children will be able to find the heights of some places near their home or school. This gives them some standard of comparison. It is helpful, too, for them to know the height of some tall building in the neighbourhood. The heights of many of the highest mountains are marked on the maps in some atlases in a similar way. The children can look at an atlas, for example Bartholomew's Comparative Atlas (Meiklejohn), for the height of Ben Nevis in the west of Scotland, the highest mountain in the British Isles, 4,406 feet high. They can compare the height of the hills or mountains in their neighbourhood with this height. In England, Sca Fell Pike is the highest mountain. It is in Cumberland, and is 3,210 feet high. In Wales, Snowdon, 3,560 feet high, is the highest mountain. In Ireland there are higher peaks than Sca Fell, but none so high as Ben Nevis.

Give the children plenty of examples of simple maps of their district or imaginary places with "spot heights" on them, as in Fig. 40. Explain how spot heights help us to read a map. Questions such as the following help:

(1) If you were walking along Wood Hill towards the hotel, would you be going uphill or down? (2) Describe the

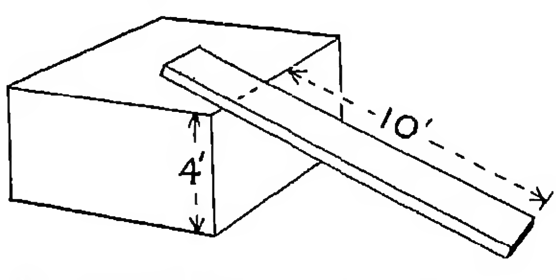


Fig. 38.—To show Slope is Greater than Height.

journey of a milk-cart from a farm S.E. of Valley Road to houses along Valley Road, Green Road, Glen Road, by the hotel to the doctor's house, and back to the farm again. Be careful to say when the cart is going uphill and when down. (3) How are "spot heights" useful to cyclists and hikers? (4) Make a map of a street or road you know that goes uphill. Mark the highest part with a dot. If you can, find out the height.

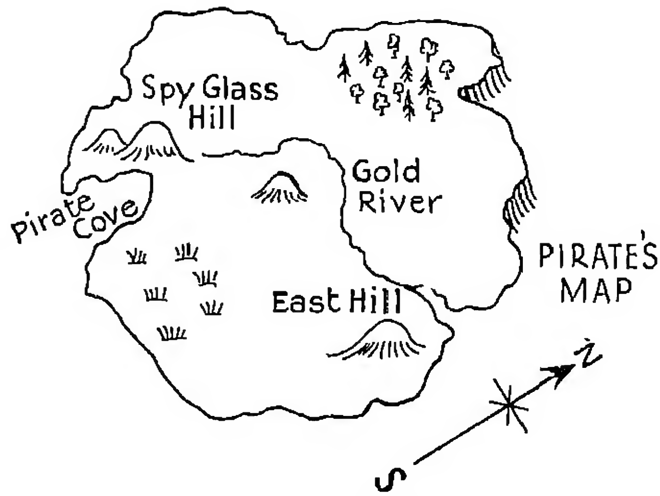


Fig. 39—Picture Map.

Colours to show Heights

Explain to the children that some maps are made especially to show where there are mountains, highlands, uplands, and lowlands. As a rule the heights are shown by different tints of green, yellow, and brown. In the corner of the map there is a key to explain what each colour means. These maps that show mountains, lowlands, and highlands are called "relief" maps.

Lowlands are generally green, uplands yellow, highlands light brown. The darker the brown, the higher the

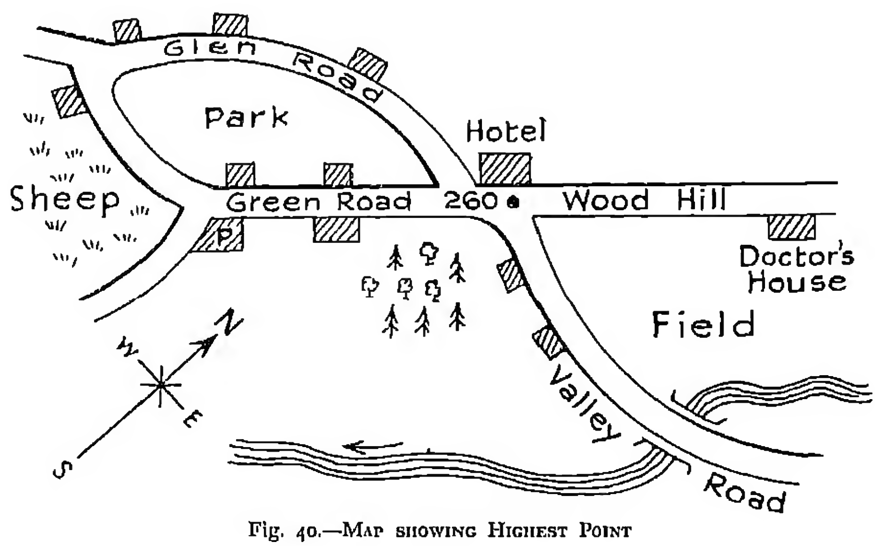


Fig. 40.—Map showing Highest Point

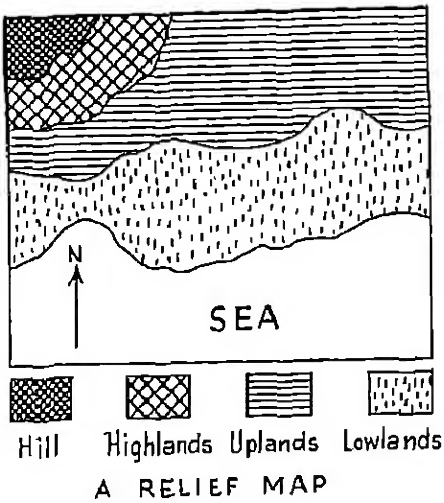


Fig. 41.—Map shaded or coloured to show Heights.

land. The highest peaks of mountains are very dark brown or purple, or white to show the snow on top. But children must always look at the key to make sure what each colour means. Impress upon the children that green means *lowland*, it does not mean grass or trees. The greens and yellows and browns do not tell what grows in these parts, but only *how high they are.* Thus *green* may mean all land up to 300 feet above sea-level, yellow all land up to 1,000 feet above sea-level, and so on. Children look at their own atlases and see what the colours mean (Johnston's School Atlas).

It sometimes helps to draw a diagram on the board like that shown in Fig. 41. Explain it to the children as it is drawn on the board. The lowest ground above the sea is marked with dots. As we go north the ground gets higher. This is shown by another kind of shading. In the north-west the shading shows that the land is higher still. The highest part of all is a hill marked by the heaviest shading. From this map it can be seen that walking by the sea to the east or west we are on low ground, but if we travel north the ground rises. The highest ground is in the north-west.

Let the children copy this map, or think out one for themselves. Instead of shading the different levels, they colour them with crayons or paints, green for the lowest land, yellow for the next highest, then brown, and dark brown for the hill. The result is a *relief* map something like the one in their atlas. The children can draw an imaginary island and colour it to show low land, and hills, etc., also river and pond.

Work for the Third and Fourth Years

Ordnance Survey Maps

These are maps that everyone should know how to read. On them are based the touring maps, cycling maps, and motoring maps which are so much used today. Explain to the children that Ordnance maps are Government maps, and they are as accurate as maps can be.

Large-scale Ordnance Survey Maps (50-inch map)

On the large-scale maps (50 inches to 1 mile), showing the region around the school, the school and school premises are easily found by the children. One sheet only of the large-scale map is needed at this stage. The map is pinned up in the classroom for the children to examine at their leisure. The school is marked by a paper flag so that no child will waste time in getting his bearings. The map of the school looks a little like the simple maps or plans that they themselves have been making.

Questions are set on the map to encourage observation, to help the children to find their way about the map, and to think; for example:

(1) On leaving the school gate I turned left and walked on until I came to the tram-stop. How many street-turnings did I pass, and what are the names of the streets?

(2) How many yards is it from the School to St. Leonard's Church? How can you find out from the map?

(3) Find on the map the quickest way from your home to the railway station. Copy from the Ordnance Map the way you go, showing the streets, etc., you pass.

Then similar questions can be asked, based on the details shown on the map.

There will be, of course, many things marked on the map that children cannot understand, and that need not be dealt with at present. Some they will recognize or guess—tramway lines, railways, streams, bridges, wooded country, etc. The children, too, will notice the spot heights. If they do not, draw their attention to them.

It is a useful exercise to set the map on a classroom table so that the " top " of the map points to true north—(the north found by the north–south line or meridian) not compass north. Small groups of children study it in this position.

It may now be necessary to speak about the difference between true or geographical north (the North Pole) and compass or magnetic north. Indeed, some intelligent children may have found that the needle in their pocket-compass does not point in exactly the same direction as the north–south line in the playground, which leads to the North Pole.

Remind the children again that we do not know why a magnetized needle points to the north. In some parts of the world the needle points *due* north. It did so in England a couple of centuries ago; on February 13, 1947, at Greenwich, it pointed about $9\frac{1}{2}°$ west of the geographical north, or "the magnetic variation was about $9\frac{1}{2}°$ at Greenwich." It decreases roughly one degree in seven or eight years; from this children can find the magnetic variation for their year.

This interests them very much. Although the magnetic variation does not matter in the first year or when the compass only is being used, it must be taken into account when a north–south line is being drawn.

The usual experiment can be performed (Fig. 42). The pupils mark off on the classroom floor or on a table a line running north–south according to the compass, placing an arrowhead at its northern end, and marking the position of the compass centre at the middle of the line. Then, using the protractor, the teacher can set off the correct angle of local variation (somewhere about $9\frac{1}{2}°$ in England) and draw another line to show a true or geographical north–south line across the one already drawn, the point of intersection being the dot already marked to show where the centre of the compass was (see Fig.) But the chief point to make clear to the children is that north on a map is always true north. On some maps compass north is given as well as geographical north.

The 25-inch Ordnance Map

The next map to show is the 25-inch Ordnance Map (scale 25 inches to 1

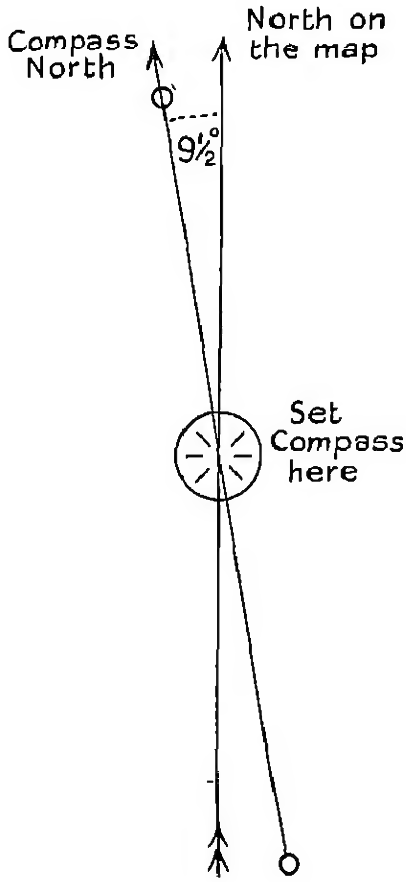


Fig 42.—COMPASS VARIATION. THE DIFFERENCE BETWEEN COMPASS NORTH (MAGNETIC NORTH) AND TRUE NORTH (GEOGRAPHICAL NORTH) IN ENGLAND IT VARIES IN DIFFERENT PARTS OF THE WORLD.

mile). This map is more interesting, as it covers more ground. Again one sheet only is necessary. With the help of the teacher the children will notice several important points:

(1) The school and playground, etc., are much smaller on this map—exactly half the size they appear on the 50-inch map. Streets, houses, woods, and other things are all half-size, too, compared with the first map.

(2) The *scale of the map* is exactly half that of the 50-inch map. *One inch* on it stands for a distance that is twice as far as that shown by a similar line on the 50-inch map.

(3) On the 25-inch map much more ground is shown. It extends beyond the limit of the 50-inch map, gives us a wider view of the country or the streets around the school. This is because 25 inches take up less room than 50 inches, yet they each represent 1 mile.

Intelligent children may see:

(*a*) That if a scale is reduced (as from 50 inches to 25) you can show *more country* on your map. If the scale is increased, say from 25 inches to 50 inches, you can show *less country* on a map-sheet of the same size.

(*b*) If a small scale is used, you may not be able to put in so many details. Some of the unimportant details have to be omitted. If a large scale is used, more details of schools, farms, and other objects can be shown. On the smaller scale more signs or symbols have to be used instead of plans.

The *spot heights* and *bench marks* along the roads should be pointed out to the children. Both show height in feet above sea-level, as found out by the very accurate and clever instruments of surveyors. Spot heights are shown by dots or small crosses; beside each is its height in feet (Fig. 40). *Bench marks* are shown by broad arrowheads; beside each is its height in feet above sea-level, as in the case of spot heights. Bench marks are cut by the surveyors on walls, stones, posts, or even on tree trunks to show levels. Children much enjoy finding bench marks near the school. After they have found the bench marks on the map, they look for them out of doors. Henceforward whatever walk they go they will be on the look-out for bench marks. One of

the good results of geography well taught is that it makes walks interesting. All children like walking for a purpose, especially to find something.

Exercises similar to those based on Fig. 40 can be prepared. A child is told to follow a road on the map from one given point to another, and say when he is going down, when he is walking on the level, or when he is going up.

From time to time children should be set to make their own little maps from the big one. Maps, for example, of the district around their homes, maps showing the way from home to certain places, and so on. On all these *maps they mark compass north by* means of an arrow.

Not too much time need be spent over this map. It is more important to push on to the 6-inch map (6 inches to 1 mile) which is so useful generally, and so frequently used in everyday life.

The 6-inch Ordnance Map

It is in the fourth year that children are at work on this map, and it may be wise to confine its use to A and B classes. Because these maps are more complicated, or seem more complicated at first sight, one map is not sufficient. One map between two pupils is, however, very satisfactory, and a quick pupil can help a slower one. Difficult as these maps may seem, the children will enjoy poring over them and finding familiar marks and symbols—spot heights, woods, roads, footpaths, houses, etc. Teachers will find all they need for lessons on Ordnance maps in two valuable little map-books:

(1) *A Description of the Large-scale Map of Great Britain*, produced and published by the Ordnance Survey, with specimens, symbol sheets and diagrams (price about one shilling).

(2) A similar booklet descriptive of the smaller-scale maps, at the same price.

These books are useful for the Primary School because they both contain a special sheet on which are all the symbols used by the Ordnance Survey in that particular type of map illustrated in their pages. Children who are naturally interested in maps will learn a great deal for themselves with the help of these symbols. The children have already collected some symbols in their self-help map booklets in connection with Plate I; now they can add more and learn to use them in the simple sketch-maps they draw for themselves. They will probably wish to rearrange and rewrite all their symbols, new and old, in groups as in the Ordnance Survey booklets—thus they will put together all the different symbols for trees and growing things, such as firwoods, deciduous trees, orchards, mixed woods, underwood, rough pasture, furze, marsh, reeds, etc. Plate I has, of course, been a good preparation for the study of Ordnance maps.

Some of these symbols may be used in connection with the English lessons. The teacher plans a simple map on the board, for example a village with a river, ford, church, windmill, fields, footpath, etc., and the children write a good description of it. The children themselves can plan maps of villages or interesting parts of an imaginary country, and then exchange papers so that each child has someone else's map to describe. Remind them that if they put a windmill in, it should be on high or open land. They can put a spot height by their windmill. It is valuable

both from the point of view of English and geography to translate a map into written English and written English into a map.

Suggestions for the First Lesson on the 6-inch Map

As soon as sufficient maps have been obtained, the lessons on them can begin. (The sheets may be obtained for school use at a much cheaper rate than that paid by the ordinary public. Application should be made to H.M. Stationery Office, or to the Director-General of the Ordnance Survey, Chessington, Surrey, for information as to how to obtain school supplies of Ordnance maps at special reduced rates. In most of the large towns of Great Britain there are agents who will provide or order any of the maps issued by the Survey. A list of the authorized agents will be found at the end of the little map-books already mentioned.)

At first sight the maps may puzzle the children. Give them some time to examine them and talk about them together. The experienced teacher will soon see when the examination has gone on long enough.

Now for the lesson. Get the children away from tiresome details, and help them to concentrate on the plain outstanding features of the map. Where is our town or village? Find the school. Where are the church, the railway station, the post office, and other important buildings. How is each shown on the map? See that the children can find their homes, and the way to school, and so on.

Then deal with the bigger features as far as one is able at this stage; for example, the *main roads or road* leading from the village to the edge of the map. Where does it lead? What important buildings, etc., lie on this map; the *railways* and the routes they follow, bridges, tunnels, etc., if any; the *parks* and *woodlands*, especially those known to the children. They can tell how they reach each from their homes; the course of the *local stream* or *river* if there is one (see Chapter VI); the positions of *factories* and *farms*, if any are shown, *country churches*, and other *schools* than their own.

Finally, let them look at the map as a whole. Where is there most open country? Where are the most woods? The large farms? Waste land? etc. Then they look again at the main roads and railways or river and see how they fit in.

Local History and Geography

The 6-inch Ordnance map is useful for linking together local history and geography, because historic remains have their names printed on it in special type that is easily distinguished from the other printing on the map. Children will delight in looking at these maps for any remains of Prehistoric, Roman, Saxon, and Norman days, etc. Indeed, it is of great value for the children to find all places of historic interest on their maps, whether these places are mentioned in their History Syllabus or not, for there is often a geographical reason for their positions. In Volume II, HISTORY, suggestions are given for collecting pictures of castles, churches, monasteries. Some of these castles may be marked on their Ordnance maps. The maps will show very often the geographical reasons for the position of castles, etc., and thus encourage the children to think about position and realize that we cannot

rightly learn one subject without the help of another. Here are some typical examples:

Castles were generally placed (1) on high mounds or crags, as Edinburgh Castle, Bamborough Castle, etc. This was for protection (HISTORY, Chapter XV). (2) On a gap in the hills through which traffic must pass. Castles were built here to guard the passage, for example Lewes and Arundel Castles on gaps in the Downs. (3) By a river for protection, etc., or at other points of strategic control such as bridges, fords, or the meeting-place of routes. When once children become interested in *position* new light is thrown on their history, and they are keen to find on their atlas every place mentioned in their history lessons. This is as it should be.

Monasteries and Abbeys are most often by the side of rivers for the sake of a good water supply, as explained in Volume II, HISTORY. Prehistoric villages and the villages of the Celts were high up on the rounded back of the chalk hills so that they were easy to defend, and away from the swamps, marshes, and woods of the lowlands.

Battlefields were usually near castles (because castles were at some strategic point, for example Bannockburn near Stirling Castle, the fight was for the castle); or near the coast at some vulnerable point, for example the Battle of Hastings.

Old trackways and Roman roads (see Volume II, HISTORY). Old prehistoric trackways run along the back of the chalk downs, hollow ways worn by the feet of the Britons. Roman roads followed some of the old trackways (for Roman roads see Volume II, HISTORY). Then there were pilgrims' ways to famous shrines, as the famous Pilgrim's Way from London to Canterbury.

Contours

Children will meet *contour lines* for the first time on the 6-inch Ordnance Survey Map. They are sure to notice strange black or red lines that wander here and there for no apparent reason. They cannot be rivers, or roads, or railways. What are they? As soon as this question is asked, a lesson on contours must be given.

Some teachers would not teach contours in the Primary School. The understanding of them is not essential as long as children can read relief maps correctly, but intelligent children who enjoy the 6-inch Ordnance Map cannot be put off if they want to hear about contour lines.

The teaching of contours is not nearly so difficult as it seems, or as it is sometimes made by elaborate apparatus. If children understand spot heights, contour lines present no great difficulty; they are merely lines joining places that are the same height. If a number of spot heights of the same level are joined, we get a contour line. Some apparatus for explaining contours needs more explaining than the contours themselves.

Here are some of the usual methods of teaching contours. It must be remembered that methods depend on the class being taught, and classes differ from year to year, so that one must be ready to change. One of the methods given below may be good with one class, and one with another. The teacher must select for himself.

(1) *The high-tide line and the low-tide line.* This is a useful method for schools near the seaside. The high-tide

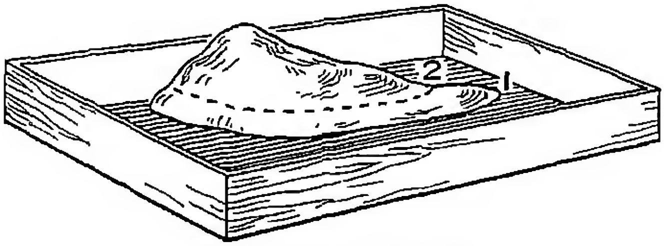


Fig. 43.—Plasticine Island.

line is often shown by strings of dried seaweed that the sea has left behind. If the children follow this line for some way, they will find that they are not going up or down but keeping quite level; such a line is called a level line or contour line. The low-tide line cannot be picked out so easily, because as soon as the water reaches its lowest point it begins to rise again and leaves no mark.

On *all* the beaches in the country when one walks from the high-tide line to the low-tide line, one goes downhill, but the distance walked varies.

When the beach is steep, as are some of the pebble beaches in Devonshire, the high-tide line is only a few yards from the low-tide line; but on the coast near the mouth of the Thames, the slope is so gentle that the beach seems almost perfectly level, and the distance between the low-tide line and the high-tide line is considerable.

Children who go to the seaside will enjoy finding these two contour lines and measuring the distance between them at different parts. This will help them to remember that on a steep slope the contours are closer together than on a gentle slope.

(2) *Clay or Plasticine and water.* A mound of clay is made and put in a large pan or small tank. Water is poured in to make the mound an island. The children notice the *shape* of the coastline, and mark the level on the Plasticine by scratching a line or making holes. More water is now poured in, raising the level to form a new coastline, shown by the dotted line in Fig. 43. Fig. 44 shows a map of the island. In this map the thick line is the coastline seen in Fig. 43; the dotted line 2 is the dotted line 2 shown in the picture (Fig. 43) when the level of the water has been raised. If the tank is deep enough, a third new coastline can be made. The children see that any irregularities in the coastline are due to the *shape* of the island at that particular level. They notice where the gentlest slope is on the model, and how this slope is shown on the map (Fig. 44).

It is necessary to make marks on the side of the tank at equal distances apart so that when water is poured in to make a third contour, this third contour is the *same vertical height* above the

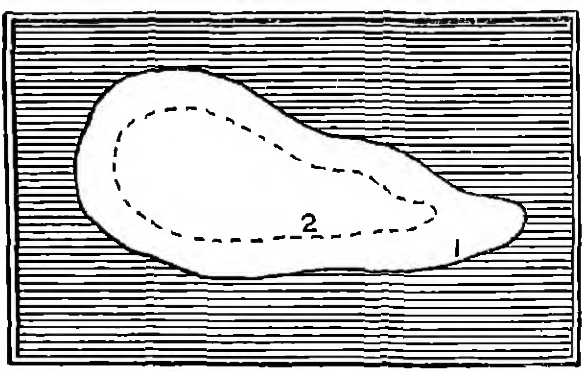


Fig. 44.—Map of Plasticine Island showing Contours.

second contour as the second contour is above the first. If only two contours are made, as in Fig. 43, the measurements at the side of the tank are unnecessary.

The water should be run off the model so that the children can discuss the contours. They see that each line joins all places of the same level and follows the *shape* of the island at that level. The teacher can now point out to the children that the word *contour* means *shape*. The children can make models in this way for themselves.

(3) Teachers who do not care to use water often model a hill of Plasticine, steep on one side and sloping on the other, as in Fig. 43. But instead of using water to show the different levels, they use sheets of very stiff paper, in which are cut the various contour shapes, so that on being placed over the plasticine hill each settles down to its right altitude, because the hole in the middle fits that particular level and no other. This model takes longer to prepare, but the purpose of the paper sheets is much the same as that of the water. They emphasize the regular differences in level, and show the shape of the land at each level. But it is quite *probable* that children can understand the meaning of contours without the use of the above models.

(4) Some teachers use a contoured model which can be taken to pieces along the plane of each contour. This is very useful if it can be obtained or made. The children see, as before, that the lines on the model are drawn to join points that lie exactly at the same level. But when the top layer is removed (that is, the part above the plane of the *top* contour), all the details on the part that has been removed are shown on the flat surface as a map. The same thing happens when the second layer is removed, and so on. Finally, when all the layers have been lifted away, the baseboard appears as a contoured map of the hill or hills represented by the model. Children learn a great deal by examining this model from time to time. They see clearly from it that each contour shows the *shape* of the land at its particular level.

The teacher must take every opportunity of emphasizing the importance of *contours on maps*. They show how the land rises in places to different levels.

(5) Some teachers let the children bring large potatoes to school and make their own little contoured models from these. The potato is cut in two along its greatest length. Not more than two contours should be marked, and the potatoes cut along the contour levels. Thus their model can be taken to pieces like the elaborate one above.

It is most important not to prolong the use of models. If the children really understand contours, models are not only waste of time but confusing. The child may tend to think always in terms of models, and not of the *contours on the map and what they mean*. Also, children, through too long use of models, tend to think that contours are made by water and not by surveyors with their instruments finding spot heights and making bench marks. Teachers tend to use models too long because children are so intensely interested in them. But models must be looked upon as means to an end, and not an end in themselves. As soon as children understand, they must use their knowledge of contours in actual

map-reading and gain more experience as they go on.

Contours on the 6-inch Map

The children can now follow with the teacher the contours marked on the map. It is a help to some children if the contours are thickened with red or blue pencil. If four or five contiguous 6-inch sheets are pasted together to form a large map, the children will see more of the contours, and the map becomes a contour map of the district. From the maps the children will be able to visualize the relief of the school neighbourhood.

Various questions may be set on the 6-inch map in connection with contours:

(1) Which is the highest ground shown on the map? Which is the lowest?

(2) Where a contour line crosses a road, the children can be told to check it by the nearest spot height given on the road, or by a convenient bench mark.

(3) They "take a walk" along a road or footpath on the map and say as they go whether the path is rising on the level or falling. Get them to explain how they know.

(4) If there is a stream or river on their map, they can see if the contours mark out the valley.

(5) They look for places where roads are steep, and places where roads are fairly level. They explain how they know. It may help some children if the different layers on the map are coloured.

Map work will be continued in connection with school walks and journeys. Preparation for the walk will be a study of a map, and the object of the walk will be the *use of the map*. Using a map out of doors is very different from talking about it indoors. Simple maps should be duplicated for the children to take with them and parts left for them to fill in. Sometimes the children will go without maps and make their own rough maps to be checked by a map when they return. Places shown on the Ordnance Survey Map become of special interest to the children. They can choose one place shown on it to explore, and then draw their own map for it.

Walks are specially valuable to notice the relief of the land, hills and valleys (see Chapter VI). They find a hill or rising ground on their 6-inch Ordnance Map; for example, they find a contour line marked 300 feet, crossing a road by a church. The road goes north-west, and farther along there is a bench mark 362·7 feet high. The children make a rough sketch of the road, and put on it anything that will help them to find about where the contour line runs. Then they set out to find it. First they find the church, which must be built on land about 300 feet above sea-level if it is near the contour. Then they walk up the road to the bench mark. They have ascended 62·7 feet. This gives the children some idea of height. They may be able to compare the height of several hills in this way, and perhaps find out that although two hills are very much the same height, their slopes vary. Short hills have steep slopes, long hills gentle slopes (see Chapter VI). How are these shown by contour? All sorts of little problems can be worked out through their walks, and children helped to see the value of maps.

Give the children maps like that

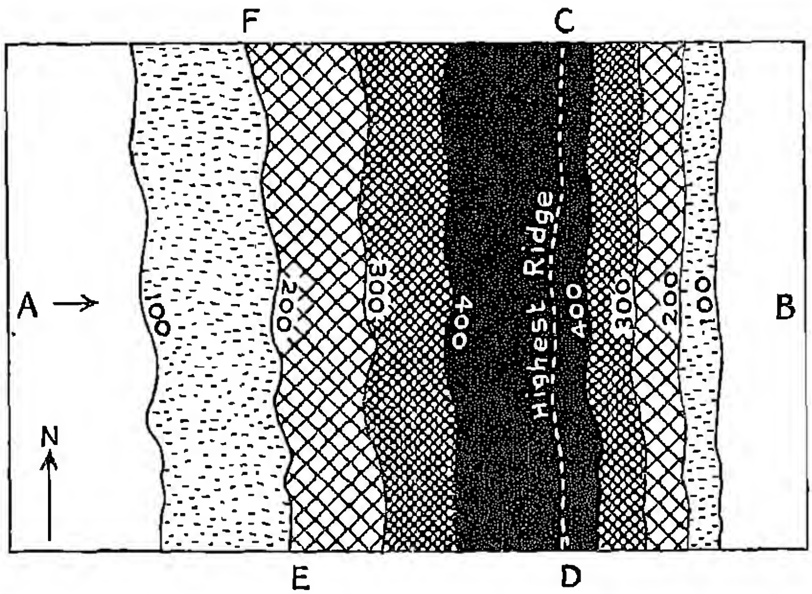


Fig. 45.—A Contour Map.

shown in Fig. 45 to study. Let them notice first that each contour has its height marked near it. Then they try to describe a journey from west to east, that is from A to B. The traveller first crosses the 100-foot contour, then the 200- and 300-foot, so he is clearly going uphill. He has to climb still higher to go over the 400-foot line. When he reaches the dotted line, he is at the end of his climb and on the top of the ridge. He crosses another 400-foot contour. This shows he has started to come downhill. He passes the 300-, 200-, and 100-foot contours one after the other until he reaches B on the east side of the ridge. Fig. 46 shows what the journey from A to B was like. The contour map (Fig. 45) shows part of a ridge of hills that runs from north to south (see direction arrow). The man who travels from A to B crosses this ridge of hills. The children can see clearly that the journey was made *across* the contours. This is important for them to remember when they are reading contour maps. When contours are crossed the road is either uphill or downhill. It is uphill when the numbers are higher, as from 200 to 300. When the next contour is a lower number, it is downhill.

If the traveller's journey followed the contour from E to F, or was parallel with a contour, he would keep at the same level all the time and not climb. On the map shown, anyone walking from north to south or south to north can walk on a level along the side of the ridge. If he follows the dotted line from D to C, he walks along the top of the ridge.

The children can see from Figs. 45 and 46 that the east side of the ridge, sloping down to B, is steeper than the west side, sloping down to A. The contours are closer together on the east side. The children, after reading maps

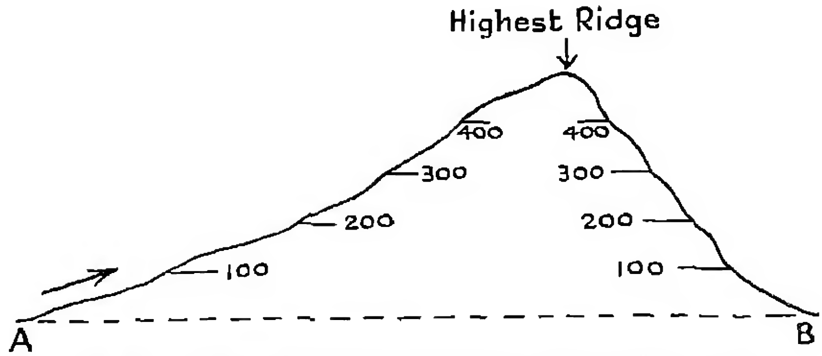


Fig. 46.—The Journey from A to B shown by Contour Map, Fig. 45.

in this way, get to know that contour lines packed closely together mean a steep slope, and they are able to pick out easily steep slopes from gentle slopes.

Any real work in practical contouring cannot be done in the Primary School. Even in the Secondary School it is doubtful whether the profit gained from it is in any way worth the time that must be spent over it.

Practical work out of doors is considered in most of the chapters that deal with local or home geography, and in many cases in those that deal with regional and world geography (see coming chapters).

The final study of atlas maps to make sure that children know something about *all* the different symbols, marks, and scales, etc., on them, is taken in the last year (see Chapter X).

CHAPTER SIX

MORE PRACTICAL HOME GEOGRAPHY

Rivers

THROUGH their walks, simple maps, and lessons on their environment the children are ready for more detailed study of rivers and valleys.

If there is a brook or river near the school, every use should be made of it. Some visits of exploration will have been made to it in the first and second years. In the third and fourth years more difficult work may be attempted.

In the case of dull and backward children, much use must be made of pictures, and picture word-cards must be made for all the new words to do with rivers (for picture word-cards see Volume I, ENGLISH, and Volume II, HISTORY). Even if these children actually see the river and have different features pointed out, pictures are still essential.

Just what practical work can be taken depends upon where the school is situated and the age of the children. The children can learn much from the observation of the "little river" made on a rainy day. They see that rivers carry along mud and sand, etc.; they wear away soil and make channels; they deposit mud, and so on.

A river-course may be modelled in the playground. The lowest part of the playground must be chosen for sea-level, river banks are built so that the *bed* of the river may be seen. The source of the "river" is in a higher part of the playground where a hill or mountain may be built. A watering-can will set the stream flowing!

Through their visits to a brook, through observation and experiments, the children will gradually become accustomed to the use of such terms as *river bed, right bank, left bank, source, mouth, tributary, confluence, current, estuary, delta,* and so on. Each term will be supplied by the teacher as it is needed, so that it becomes naturally a part of the child's vocabulary; for example, the first part of a river noticed is generally the *bank*. Tell the children the names of the banks. To find out which is the right bank we must imagine we are looking in the direction in which the river is flowing, or sitting in a boat drifting down the river and facing the direction in which we are going (Fig. 47). The right bank is then to our right. On a map that shows only part of a river, an arrow is put to show the direction in which the water is flowing. Thus the right bank and left bank are easily found. On a map that shows the whole of a river (Plate III), the arrows are not necessary, as we know the river must flow from the higher level of the land to the lower level of the sea which is shown on the map.

If we are in a boat on the river rowing towards the mouth, we say we are

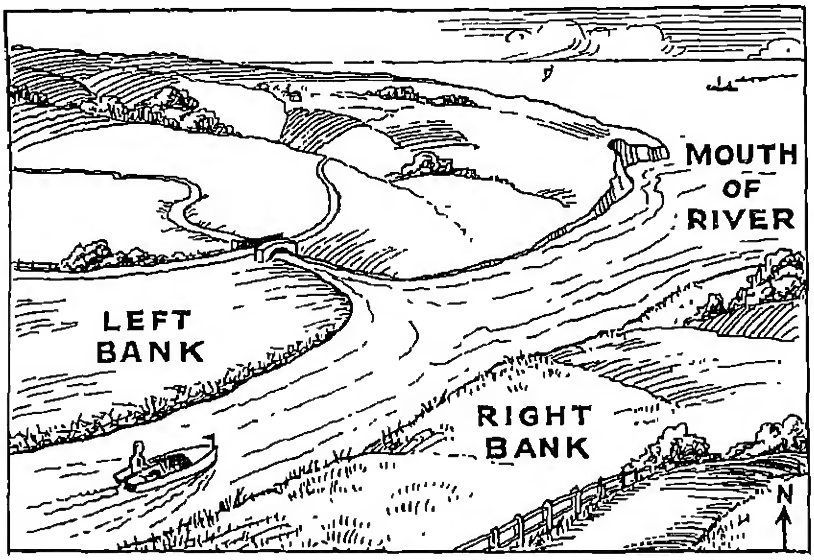


Fig. 47 —A Boat going Downstream.

going *downstream*. If we row towards the source, we go *upstream*.

The children draw maps of their brook or their model rivers, or parts of the brook to show the direction of the current or which way it flows (paper boats will tell them this), the names of the banks, and boats going *upstream* and *down*. Underneath their map they explain clearly what it shows.

Let them study how a river is drawn on a map. It is generally a line thin at the beginning and getting thicker as it nears the sea, to imitate the widening of the river itself as its tributaries bring more water to it. Plate III is useful for summing up a child's knowledge and for reference. Children are rarely tired of looking at it, tracing the course of the river, finding its many tributaries, and so on.

Talks about rivers can be given in connection with the children's map and Plate III, thus—

We often say a river *rises* at a certain place, as, "The Thames rises in the Cotswold Hills," that is, the Thames begins or has its source in the Cotswold Hills. As the source of a river is often a spring bubbling out of the ground on a hillside, it is not odd to say that a river *rises*. As a river flows along, it generally becomes larger and larger because other streams join it and flow along with it. The place where *one stream* joins another is called a *confluence*, or *flowing together*.

A *large* river is one that carries a great deal of water. It is both wide and *deep*. A *long* river need not be a large river, because it may be narrow and shallow. The *largest* river in the world is the Amazon in South America; it brings more water to the sea than any other river. The *longest* river in the world is the Mississippi, with its tributary the Missouri, in North America. The Missouri-Mississippi is 4,502 miles long, and the Amazon is 4,000 miles. The longest rivers in Britain are the Severn, 220 miles, and the Thames 210 miles long. It is well to

remind children that not all tributaries are shown on a map as a rule, as it would make such a network of lines. Tributaries, it must be remembered, may have smaller tributaries feeding them, and these may be fed by smaller ones again.

The children are often confused between the words *mouth* and *estuary*. The place where a river joins a sea or lake is called its mouth. The *estuary* is the part of the river up which the tide flows. Above the estuary the tide is not felt. The estuary of the Thames ends at Teddington, because the tide is not felt beyond this place.

Let the children practise drawing maps of imaginary rivers. They put bridges across for roads or railways; they show fords, etc. Make sure that through their *observations,* models, and practical work generally, the children learn some definite facts of future value as given below:

The Work of Rivers

Rivers are always working. The children will have seen for themselves how even a tiny trickle of water, after a shower, cuts a little channel in the sand on the roadside. Remind the children that rivers work in the same way. As a river moves towards the sea it wears away the banks and cuts the bed deeper; swift streams are able to roll stones and gravel along, and slowly flowing streams carry mud. This mud is made of tiny particles of rock which the water has worn away.

Children will learn much by exploring a river, especially where it bends. Let them look particularly at the banks on both sides. Running water always chooses the easiest way, and therefore if it comes to an obstacle it flows around it, thus causing a bend. Let the children throw a stick into the middle of the stream at a spot above the bend. They will find that the stick is carried to the outer side when nearing the bend, as in Fig. 48. The water has more distance to go on the outer curve and therefore flows more swiftly than on the inner side of the curve. The arrows in Fig. 48 show where the current is strongest. Where the current is strongest the bank is worn away by the wash of the water. On the opposite side, where the flow is gentle, mud is dropped until gradually a mud bank grows and appears above the water (Fig. 48).

Besides building up its banks, a river sometimes forms islands in its course, and islands at its mouth called deltas. *It is when a river slows down that it drops the mud that it carries.* It is

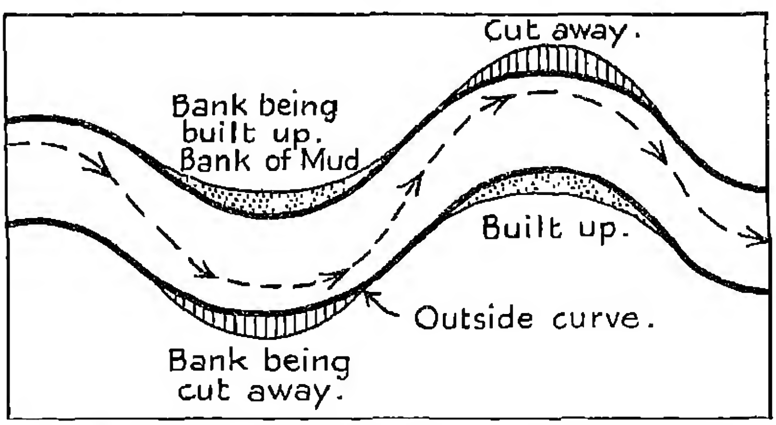


Fig. 48.—The Dotted Line shows where the Current is Strongest

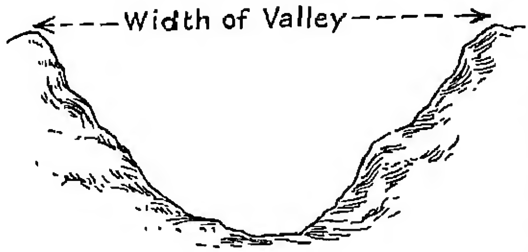


Fig 49—A Valley with Steep Sides.

slowed down sometimes by a big stone or some obstacle in its path. Here mud accumulates and an island is built up. Little brooklets and small streams often show miniature islands formed in mid-stream. The islands of the middle Thames can be pointed out to the children as larger examples of the same thing (Plate IV). A river is also slowed down when it reaches the sea. Much of the stuff it brings down must be dropped on the sea floor around the river mouth. In the case of most rivers this material is nearly all swept away by the tidal currents in the sea. When seas are tideless or nearly so, as in the case of the Mediterranean, rivers tend to have large deltas at their mouth, as the Nile in Egypt. The children will remember the Nile delta from their history (see Volume II).

The two chief factors that make a stream run fast are—first, and most important, *the slope*; secondly, and less important, the sudden increase of the water through rain or by the flowing in of tributaries.

But it is in the upper part of its course, where its bed is steepest, that the brook or river does its most destructive work even though its volume is smaller. With A children one may introduce such difficult words as *erode, gorge,* and talk about "the brook *eroding* or wearing away its bed and widening its little *gorge* or valley."

The destructive power of rivers will be brought up again when speaking of the *gaps* across the Pennines worn by rivers, the Tyne Gap, and the Aire Gap (Chapter X).

Valleys *(Plate IV)*

We cannot talk about rivers without talking about valleys, because many valleys have been cut out of the land by *running water.*

In their walks the children have noticed the hills and slopes around (see Chapter V), and they know how high land and low land are represented on maps, but many children have few experiences of valleys, and nearly all children are very vague about them.

Whenever two downward slopes come together a valley is formed. Figs. 49 and 50 show simple ways of drawing valleys. Some valleys have very steep slopes, as in Fig. 49. Others have gentler slopes and are wide, as in Fig. 52. Let the children model some valleys with clay, sand, or earth in the garden, or with Plasticine indoors. Let them show by their models that valleys have

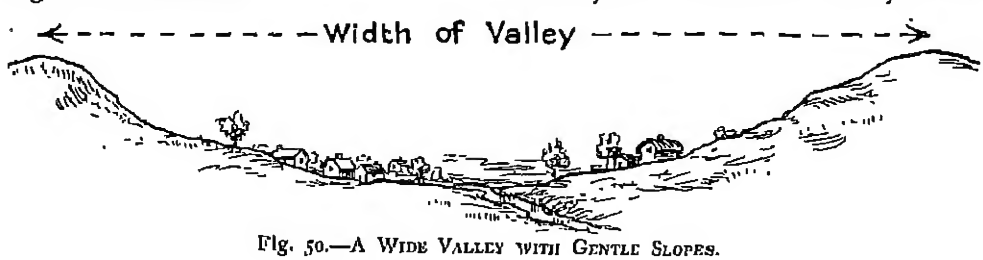


Fig. 50.—A Wide Valley with Gentle Slopes.

length as well as width, and that some valleys are very long and some quite short. They themselves may live in a valley that is many miles in length. Let them find out about their own valley. Remind them that some valleys are so broad that one cannot see across them, and the slopes are so gentle that many people who live in them do not know that they are living in a valley.

Why is there generally a pond, lake, or river at the bottom of a valley?

Let the children study the pictures of river valleys (Plate IV). From their experiences they can read much from these pictures. Let them describe each valley. How has the island in the Thames been built up? Tell something about the left bank and the right bank of one of the rivers.

Let the children collect pictures of valleys for a class picture-book. This will make them familiar with many different types of valleys if they are carefully chosen. Plate IV, for example, shows clearly what a *gorge* is, a narrow valley. It is a view of the Avon Gorge, looking up the river towards Bristol. In the left foreground is the bare limestone. Valleys in limestone rock are generally steep-sided (cf. Cheddar Gorge). Let the children notice the wide mouth of the Shannon. The children's study of world geography and the British Isles will introduce them to many valleys.

Children often have difficulty in understanding the width of a valley. They think the valley is just the part through which the river flows, and includes only the banks of the river. Figs. 49 and 50 may help them. Fig. 51 shows a sketch of two valleys that give further help to the children in under-

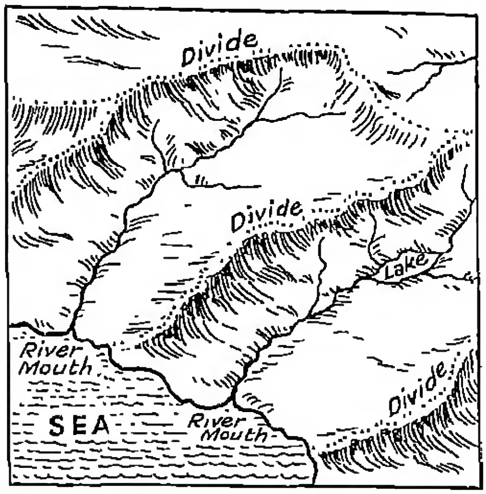


Fig 51—VALLEYS AND DIVIDES.

standing the width of a valley. Rain falls into each of these valleys, some of it sinking into the soil and some running off down the slopes. Into which valley will the water flow that falls on the top of the ridge? Think of the rain falling on the roof of a house. When it rains upon the roof of a house, the water is divided along the highest part, some flowing down one side, some down another (Fig. 52). The same thing happens when rain falls on high land or mountains. Because the water parts or divides at the highest place between two valleys, this place is called a *divide* or *water-parting*, or sometimes a watershed. The dotted lines in Fig. 51 show some *divides*. Point out to the children that divides are often very irregular, and difficult to find because the land where they are may appear to be flat. Perhaps the children can find a place in Fig. 51 where the divide is lowest.

If you wished to know how wide one of these valleys is, where would you begin to measure it? The children will

see it will be from the "divide" on one side to the "divide" directly across on the other side (Figs. 49, 50, 51). This is so because the "divides" form the boundaries of the valley. The children notice that the *valley* is much wider than the *stream*, especially in Fig. 50.

The children make valleys in clay or plasticine to show some *"divides"* or *"water-partings."* They may be able to find a "divide" in their neighbourhood. They are sure to be able to find some little valleys which may or may not have a river. Let the children notice that streets and roads are generally made so that they have a watershed or "divide" running down the middle, shedding or dispersing the water into the gutters on each side. This encourages observation and helps children to realize that a good deal of geography can be learnt from the everyday things around one.

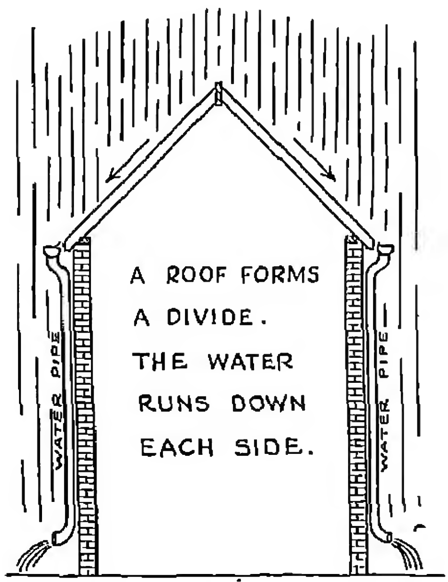


Fig. 52.—A Divide, Water divided along the Highest Part.

River Basin *(Plate III)*

Plate III will help the children still further to understand *divides*, and introduces them to a river basin.

Help the children to realize that a river entering the sea may have received water brought by hundreds of tributaries. Thus the rain that falls in places even hundreds of miles apart may at last be brought together in a *single* main stream. Such a main stream with all its tributaries is called a river system (Plate III).

All the country which is drained by a single main stream and its tributaries is called a *river basin*. Thus all the land drained by the Thames is called the Thames basin. Some children may live in the Thames basin. Let them find out if they live in a river basin.

Remind them not to think of a river basin as a true basin. A real basin has a rim extending *all* around it. The rim of a river basin is the "divide," which may be very irregular in shape, and there is no rim or "divide" near the mouth of the river, since the water runs into the sea.

The children will learn a good deal from studying Plate III—the meaning of source (beginning), tributary, confluence, estuary, etc. Let them draw a map of a river system for themselves and put in all the features they know, especially the river basin, so that they are quite sure what it means—all the land drained by a single river and its tributaries.

The children will study the river nearest to them. Fig. 53 shows the Severn basin. Outside the dotted line streams flow away to join other rivers. They belong to other basins.

Thoughtful children may wonder where all the water comes from that fills

the great rivers. Especially if they have noticed that small streams dry up and disappear soon after rain. Even large brooks may become quite dry in summer. Why do large rivers never dry up?

One reason is that many rivers have a constant supply of water at their source. This is true of a stream starting in a high mountain, because the snow on very high mountains never entirely melts away. In summer it only melts the faster, so that streams from the mountains, far from drying up, are more swollen than usual. It is also true of streams that have their source in deep lakes or swamps. In England the constant supply of water that feeds our big rivers is generally *springs*. There is a great deal of water in the ground. It is this which men find when they dig wells. This underground water trickles through crevices in the rocks, often bubbling forth as a *spring*. Many large rivers are supplied from hundreds of such springs. The Thames begins as a little spring on the Cotswold Hills.

Looking at Plate III, children will realize that a great river with its many tributaries flows through a very large tract of country, so that when it is not raining in one part the rain may be falling in another. Thus, while one tributary carries little water, heavy rain may keeps others full, and these flow into the main stream, preventing it from drying up. Sometimes, indeed, through heavy rains, and snows melting too rapidly, so much water may flow into the main stream that it rises and overflows its banks. The Thames sometimes overflows its banks.

The children make self-help booklets about rivers and valleys. They have a special page for all the facts they dis-

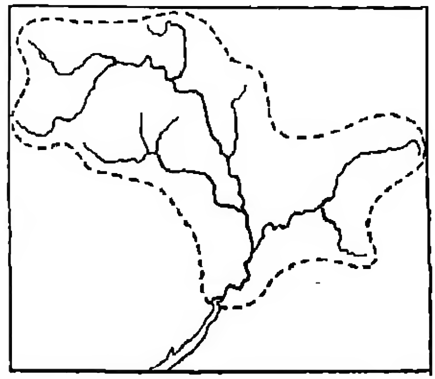


Fig 53.—The Severn Basin.

cover themselves; for example, (*a*) The rate at which the river near them flows. Paper boats or boats of some kind will help them to discover this. (*b*) Where a river has a bend the water flows more rapidly on the outside of the bend (Fig. 48), and so on.

Many like to make a River ABC. In it they write all the words to do with rivers and river valleys: thus for B there is *basin, bed, bends, bank*; for C, *confluence, current*, etc.

The third and fourth year is a good time to study rivers, as the children are then old enough to learn a great deal from geographical expeditions. Exploring some of the famous rivers of the world makes an interesting course for the third or fourth year, and teaches much world geography as well as home geography, as they must take a famous home river. In their study of the British Isles in the fourth year, they will probably explore the Thames, Avon, Clyde, Shannon, etc. (see Chapter X).

Ponds and lakes may be treated in the same way, but they are less important at this stage. Lakes will be met with in their study of the British Isles.

Other Suggestions for Local Study

THE SOIL

The children should know something about the soil in their neighbourhood. The separation of soil into its main constituents, soil experiments, and the study of clay, sand, etc., are dealt with in the third year's work in NATURE STUDY AND SIMPLE SCIENCE, Chapter IV, Volume IV. The children can add to their knowledge in the geography lessons. Expeditions may be made to sandpits, chalkpits, and quarries if possible.

Rock changes to soil most rapidly near the surface; for the rain, roots of plants, and earthworms can reach it more easily there than elsewhere. So the deeper into the earth one goes, the less the rock is changed (Fig. 54), and no matter where one digs, if one should dig deep enough one would come to solid rock. Children can observe this for themselves (*a*) by looking carefully at the sides of a steep cutting when travelling by train through hills, (*b*) by visiting a quarry and examining the sides. At the top there is a layer of soil in which are the roots of plants and trees. Below this the soil is coarser, and there may be large and small stones and fragments of rock mixed with it. The roots of the larger trees grow down into this. It may be chalk or some kind of harder rock. Sometimes the rock lies in bands, as though one layer had been put down on top of another. Sometimes the layers of rock are bent and look like huge arches. If one could see the sides of a cutting made right through the Pennines, it would show bent rock layers of this kind (Fig. 55). In the middle, forming a kind of core, is a very hard kind of limestone. This limestone is quarried and used for building stone or street paving. The arch above the limestone is made of sandstone. Sandstone is made of hard grains of sand fastened together by time and nature to form hard rock. In Pennine sandstone the grains are so firmly fixed

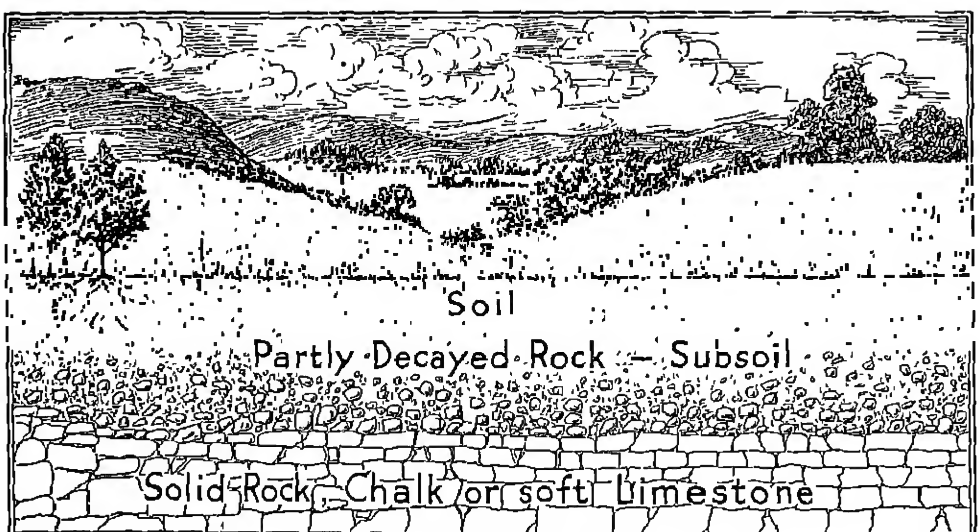


Fig. 54.—SECTION OF EARTH TO SHOW SOIL AND SOLID ROCK. SKETCH FOR TEACHER TO DRAW ON THE BOARD, AND THE CHILDREN TO COPY. NOTICE THE ROOTS OF PLANTS AND TREES.

Fig. 55—The Side of a Quarry showing Layers of Limestone Rock

that the rock is very hard and gritty and makes excellent grindstones. Fig. 54 is a useful drawing to put on the board for children. Let the children tell what they can see in the picture—the soil, subsoil, roots of plants, roots of trees on the left; the solid rock underneath is chalk or soft limestone. Children like to make this drawing for themselves. Underneath they can write the names of some of the things that cause rocks to break up and decay. All rocks have cracks in them, some that can be seen and some very tiny. (1) Water steals into the cracks and wears the rock away. It may freeze in the cracks and break off pieces of rock. (2) Plants push their hair-like roots into the cracks; when the roots grow bigger they break off pieces of rock. (3) Earthworms help to break the smaller pieces up. Sometimes the soil is so deep that men may dig deep wells without finding rock; while in other places there are only a few inches of soil, hardly enough to hide the rock.

One reason for such difference in the depth of soil is that some rocks decay more easily than others. Another reason is that in some places the rain washes the bits away as fast as the rocks crumble. This may leave the rock bare in one place and make the soil very deep in another—but *beneath all soil there is solid rock*. Let the children think how different it would be if no rock had ever changed into soil.

For their geography museum the children should collect specimens of rocks in their neighbourhood and also have specimens given them of rocks in other parts—sandstone, limestone,

chalk, granite, slate. These rocks are all used for building. Such a collection is of great interest and value to children. The above work is again suited for the third year and fits in well with the suggested syllabus "Other People's Houses."

The children will also like to collect specimens of garden soil, clay, sand, etc.

The Ocean and the Seashore

Schools by the sea have the advantage of much valuable geographical material suggested by the coastland, bays, coves, headlands, river mouths, harbours, the nature of the shore itself, sand, rock, mud, etc., and the effect of the tides. Inland schools must do all their "practical work" with pictures (see Plate XX), unless a journey to the seaside is possible.

On the seashore the children can see examples of rocks being worn away by wave action and sea erosion, as well as by the action of wind and weather. The rounded and smooth pebbles are the result of the waves crashing and grinding stones together, and the tides sweeping along the sea-bed and pushing and rolling pebbles and shingle before them.

Local ports and harbours are of interest and importance. Children can find answers to these questions: Why are piers and breakwaters necessary? What steamers and ships come and go? etc. Children are interested in collecting all the ways in which the ocean is useful to man: (1) As a great waterway connecting different parts of the world by means of ships. (2) A supplier of food, fish. (3) Water. It makes rain possible. (4) The seashore is a popular summer resort and often a winter resort, because the winds that blow over the sea are cool in summer, and warmer than land breezes in the winter. The sea keeps its summer warmth longer than the land.

Many children have spent holidays at the seaside, and if their information is pooled, much of value is learnt by the children. Lessons where the children contribute information need to be carefully managed. Children are so eager to tell something themselves that they rarely listen to their companions thoughtfully. Well-arranged questions on the part of the teacher often keep the information on the right lines. Suitable headings on the board, to which the children contribute sentences, also help. Children themselves should produce a little summary of what they have learnt at the end of the lesson. A summary that is the result of sifted information is of great value.

Let the children collect from magazines, picture postcards, advertisements, etc., pictures of the sea—coast scenery (Plate XX), ships, lighthouses. A well-arranged collection is of great value. Not *every picture* about the sea should be used. Any collection that shows thought should be praised, even if it is a little untidy (see Chapter X). Useful collections of rounded stones, seaweed, shells, etc., can be collected; also pictures of plants that grow near the sea.

CHAPTER SEVEN

REGIONAL GEOGRAPHY FOR THE FIRST YEAR

SIDE by side with local geography will go regional and world geography. Local geography or home geography should not be treated as a special subject and an end in itself. It should be linked as closely as possible with the lessons on regional and world geography. The children must see and think of their home, town or village, county and country in connection with the great world around, of which it is a part. To confine the children of any class to local or home geography only is both unsound and unfair to the children. A child naturally wonders what is beyond the next bend of the road, and the next, what lies beyond his village or town, what lies beyond his country. Although practical work and experiences are all-in-all important, the child needs something apart from these to stir his imagination and his emotions, and to satisfy his genuine curiosity. Stories of life in other lands, lands very different from his own, help to satisfy this need.

The study of the British Isles should be left to the third or, better still, the fourth year. The geography of England and Wales, Scotland, or Ireland is a difficult and involved problem for young children to tackle. They have not enough general geographical experience to distinguish between things that differ slightly. They can only see big differences. In a sense they are beginning the geography of the British Isles in the first year because of their lessons on local geography, but these being mainly practical make an instant appeal to children and help them to build up experiences. From these experiences and from those they gain from nature study, the children are able to tackle later a more detailed survey of the British Isles.

Many interesting syllabuses can be arranged to make the younger classes familiar with far-away lands and people, and with the arrangement of the great land and water masses of the world. These syllabuses may be based on three topics of great interest to children of every age and even adults, namely, building homes or houses, food, and clothing.

Other People's Houses, or Shelters and Homes all over the World

The first year's work might well deal with this topic. It fits in well with the History Scheme (see Volume II), for in history they are learning about homes of *long ago*. If sufficient time is given to the topic, intelligent children see that some of the homes of long ago can be found in the world today, cave dwellers, tree dwellings, huts, windbreaks, etc. (see *Other People's Houses*, Harrap). The topic can be based on

home geography, for, as we have said before, home geography must go on with regional geography.

The lessons begin with children telling about the houses in their own town or village. Have they ever seen a house being built? Get from the children, if possible, the materials from which the walls of houses are usually built: brick, stone, concrete, or wood. Which of these things is most used in your town or village? Of what are the walls of your house made?

Children are especially interested in bricks. If brick-fields are near, they will of course visit them. Bricks are made from clay or clayey earth known as *brick-earth*. Impress upon the children that clay must be mixed with something else to bind it together and make it more plastic. In the London district the brick-clay is mixed with ground chalk; in Bible days we know that chopped straw was mixed with mud or clay as a binding material. The children themselves can experiment, and make toy bricks, using, say, a matchbox for a mould. They can try to build a brick wall, arranging their bricks in the right way. This makes an interesting and valuable handwork lesson. Most of the information a child will need about bricks will be found in *Other People's Houses* (Harrap).

Brick-making works in well with the history. Brick-making dates back to very long ago. Remind the children of the sun-dried bricks of Egypt, Babylon, and Assyria, and so on. Let the children think why bricks are better than wood and cheaper than stone. Where do we get stone? There may be stone quarries near the schools; if so, the children should visit them (see Chapter VI).

The materials used for roofs are slate, tiles (clay), thatch, or corrugated iron. Which of these materials is most often used? With which is your house roofed, and other houses near yours?

In Wales children will be most familiar with slate, in London tiles, in villages thatch. The actual lesson and activities will depend upon the locality of the school.

Children will now be interested to know what materials are used in other parts of the world, and what different kinds of houses there are. Are there places where no bricks are made or used? Where are they? The teacher will choose homes and shelters in different parts of the world to show the different conditions under which people live. This regional geography is the beginning of world geography. Homes in the following regions might be selected:

(1) *The Cold Lands.*—Snow-houses, tents, huts of stone or sods of the Eskimos of North America and Greenland, Lapps and wandering tribes of the tundra of Northern Europe and Asia, tents and sod-houses. (Plate V.)

(2) *The North Temperate Lands.*—(*a*) Cool forests: log-houses of the Canadian forests. (*b*) Cool grasslands: tents of the Red Indians in North America, felt tents of the herdsmen of the steppes of Asia. (Plate VI.)

(3) *Hot Deserts.*—Tents, and houses of sun-dried bricks or stones in the oases. (Plate VI.)

(4) *The Tropics.*—(*a*) Hot forests: homes of the pygmies and the negroes of the Congo, homes on the Amazon. (*b*) Hot grasslands of the Sudan, and savanna lands of Africa. Some grasslands are park-like, with trees as well as tall grass. These are the grasslands

nearest to the hot forests or where there is plenty of rain (see map, Plate VIII).

(5) *Warm South Temperate Lands.*—There is much less land in the South Temperate Zone and therefore fewer houses. (*a*) Homes of the farmers on the grasslands (pampas) of South America. (*b*) Kraals of the Kaffirs of the grasslands of South Africa. (c) Homes of farmers in Australia and New Zealand, very like our homes in the North Temperate Zone. The rough shelters of the "Blackfellows" of Australia are interesting from the point of view of history. But Australia and New Zealand are the homes of white people. The children must not confuse Australia with Africa. Africa is really the home of the black people. A large map of the world is pinned up so that when the children have learnt about a certain dwelling, a flag can mark the place on the map where it might be. There is a useful map of the world in W. and A. K. Johnston's (Edina Works, Edinburgh) *School Atlas of Great Britain and Ireland* which the children can use themselves in connection with these lessons.

The children quickly notice as the lessons proceed how cleverly people use the material at hand for building, and how houses are adapted to material and to climate.

Plate V is a useful picture of shelters in the Cold Lands of the North. Remind the children that the Eskimos have many different kinds of homes according to the part of Northern Canada, Alaska, or Greenland in which they live.

Many Eskimos now live in villages built of wood, or stones and sod. The wood comes from the great forests that lie south of the Cold Lands, for there are no trees in the Cold Land. Some Eskimos who live in villages keep tame reindeer brought from Northern Asia. The caribou, the reindeer of the polar region of North America has never been tamed by the Eskimos. They use dogs to draw their sledges. The tame reindeer belongs to Northern Europe and Asia.

Plate V shows the home of Eskimo hunters in summer and winter. The snow-house or igloo is important because it helps children to realize how cold it is in the Far North. With nothing but snow and ice around, shelters must be built of this material. Blocks of snow are cut with a large knife into bricks, and shaped to make a round hut. Fig 56, A, B, C, shows the sloping of the blocks and how they are cut so that the second row of blocks starts on an angle upwards. Finally,

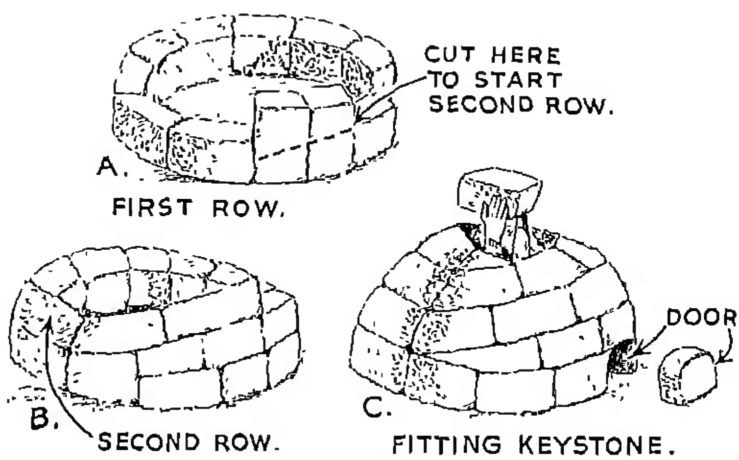


Fig. 56.—Building an Igloo.

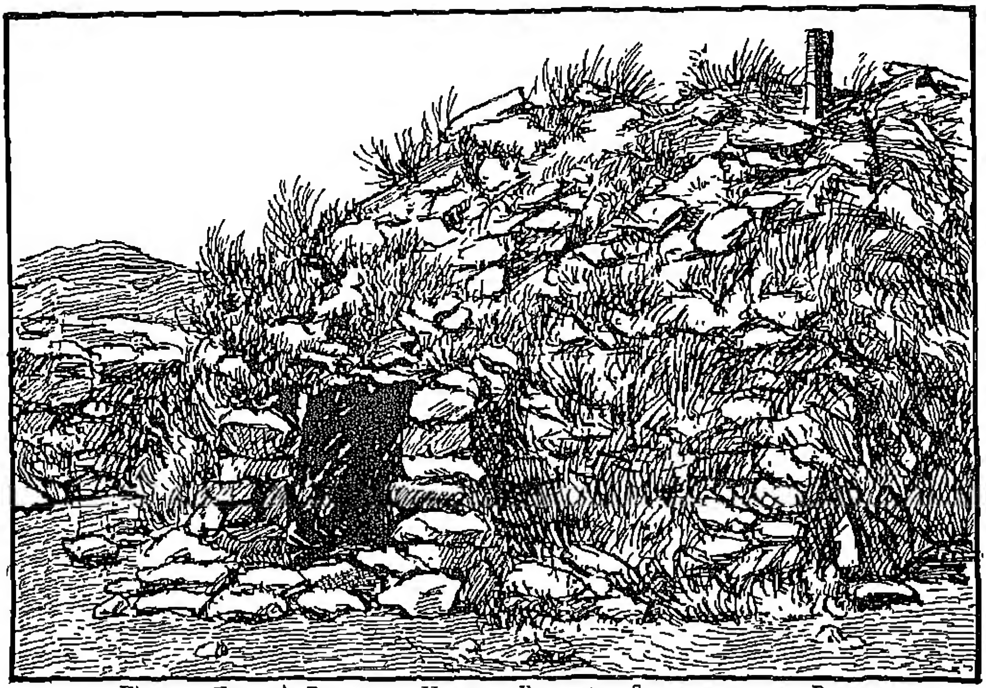


Fig 57.—Eskimo's Permanent Home of Rocks and Stones from the Beach.

about the fifth or ninth row, the spiral of blocks comes together. Only a rough rectangular opening is left in the very top of the igloo. Into this opening the keystone block is carefully fitted, as in Fig. 56, C. The Eskimos build their igloos so carefully that every block does its share in holding up every other block. Some fifty blocks are needed about three feet long and two feet wide. The finished igloo is shown on Plate V. All joins are carefully filled up with snow. It is well for children to realize how clever the Eskimos are at cutting their snow blocks just the right size and shape, and choosing snow that is not too soft or too hard. This building needs skill, patience, and knowledge, and it is just the right house for a polar winter. It is much warmer, safer, and more comfortable than a tent. Inside there is plenty of room for a platform of snow, covered with skins, on which the hunters can sit or lie down at night. No blizzard can knock it down, and an Arctic blizzard will sometimes last for days. Eskimos out hunting would perish in these blizzards if they did not know how to build an igloo.

The igloos are built in winter anywhere where the Eskimos want to stay for a short time when hunting the polar bears or seals. They often build them near the frozen ocean, where the ice is not too thick for the seals to make breathing-holes. They stay in their white village until they have caught enough seals, and then return to their more permanent homes built of sods and stones from the beach (Fig. 57).

Like the igloo, the hut of sods and stones has a passage leading to the living-room. The walls are hung with sealskin, and there is a platform of

stones, covered with moss and soft skins, where the family both sit and sleep. In the centre is the oil-lamp with its wick of moss, which is always kept burning. This gives light, and—what is more important—heat. Without this lamp the Eskimos might perish in the winter, especially in December and January, when it is too dark to hunt seals. But if they have a good stock of oil, frozen seal meat, and frozen fish, life in their snug winter home is quite pleasant, for they are busy all the time, the women making clothes from skins, the men repairing their sledges, hunting weapons, and traps, making knives from whalebone for cutting snow, or carving toys from bone for the children. They also pay visits to their neighbours.

As the temperature must be below freezing-point in order to build an igloo that is satisfactory, in summer a tent is used (Plate V). In the olden days the Eskimos made their tents of sealskins, supported by the large bones of animals or by driftwood that had floated down rivers like the Mackenzie from much farther south, and been cast ashore by the sea. The children look at the picture on Plate V and tell how the tent is made—from sealskins sewn together and a few short supports. They notice that heavy stones are put around the tent to make it snug and warm. (Today most of the Eskimo hunters buy wood and tents from trading-posts such as the Hudson Bay Stores, where they go to sell their skins) Inside their tents, they have beds of dried moss, covered with caribou skins, oil-lamps of hollowed-out stone over which they cook. Their oil, of course, is the fat or blubber of the seal and walrus. Plate V shows also how the Eskimos travel in summer and winter.

The children can tell about this, and also find out about the animals and fish caught by the Eskimos, such as the seal, walrus, caribou, bear, musk-ox, Arctic fox.

Through their study of pictures and through talks, children begin to realize that it gets colder and colder the farther north one goes. The sun's arch in the sky gets lower and lower, so that in the very Far North some of the winter months are without the sun at all. The pines and firs of the cool forests disappear and in their place are moss, reindeer moss, low bushes, and plants. Still farther north there is no vegetable life at all.

Through their nature-study lessons children know how far the roots of a tree extend underground. In the Cold Lands or polar regions the ground is always frozen. Only in the summer does the *surface* thaw, and here moss and plants with *short* roots grow. The winter snow protects them and the warmth of the short summer brings them to life again with gay flowers. The roots of trees go down so deep that they would be always frozen. The children's maps will show them where the cool forests of pines and firs end, and where the cold Arctic lands begin where no trees can live.

To give the children a good word-picture of the frozen North, read to them the story of the famous sailor Bob Bartlett, which tells how he learnt from an Eskimo to build an igloo. He had just had a narrow escape from an Arctic blizzard and saw the need for knowing how to do this. This is a true story and of real value for the geography lesson. It will be found in *The Romance of Reading*, First Series, Book IV, "Cosy Company" (O.U.P.).

In their handwork lessons the children should be allowed to try to make igloos of blocks of Plasticine or clay. They must shape their blocks carefully so that they tilt slightly inwards and form a spiral. The Plasticine blocks tend to stick together, but the children must try to arrange their blocks so that they support each other and hold together, not because they *stick* to each other, but because they are all well placed. Then, lastly, they fill up the cracks with Plasticine and make it proof against wind. A small air-hole must be left. This is made by pushing a matchstick or some such thing through one of the blocks at the top, and when the igloo is finished pulling it out. The door and entrance tunnel of the Eskimo igloo also give some ventilation, although in bad weather it must be blocked up with a snow doorway.

Even if children fail to make a successful model, the trying leads to thought and understanding. Beautifully finished models are rarely of much value from the point of view of teaching. There is still less point in children making model igloos of eggshells covered with cotton-wool, etc.

Plate VI shows dwellings in the North Temperate Regions—the cool forests and the cool grasslands. Again houses are built of materials near at hand. Logs, for example, are used in the forests; but in the steppes, the plains of Asia, the only wood the wandering herdsmen (the Kirghiz and other tribes) have are the branches of the stunted willows that grow on the banks of rivers that often dry up in the summer. From these straight, pliant branches they cleverly make a kind of lattice-work as shown on Plate VI. This is covered with felt made from the wool of their sheep (felt is made by spreading out wool in a thick layer and beating it with rods. The wool is then damped and rolled up tightly. This mats it. Later the children can compare matting and weaving; weaving is more difficult).

The Kirghiz, being herdsmen, live a wandering life searching for food for their flocks and herds, for the grass in one spot is soon eaten. They have horses, asses, and camels to carry their goods, and hundreds of sheep and goats. Their cleverly-made tents are taken down and put up very easily. But now more and more of these tribes tend to live a settled life. The children can compare the lives of these wanderers with the wanderers they are learning about in their history lessons, Volume II. Children may want to know why no trees grow in the grasslands. Here again their nature study may help them. Trees need a great deal of moisture, much more rain than grass needs, because of their long roots. The steppes are too dry for trees. The children can look at the maps in their atlas that show dry lands and wet lands—lands with little rain, well-watered lands, and very rainy lands.

Many teachers may like to include in their syllabus the prairies or grasslands in the west of North America where once the Red Indians of the plains wandered. Although now they are mainly cornfields or cattle ranches, it is well to remind the children that once they were wild grasslands. With backward classes lessons on the Red Indians and their tents arouse interest. They are the *hunters* of the prairies. The children can compare the life of the hunter with the life of the herdsman. There are good pictures, showing

the correct patterns and colour of Red Indian tents, in *Other People's Houses* (Harrap). Children will learn much from drawing and painting these tents, and trying to make them in the handwork lessons. Children should compare the Red Indian tent, a typical western tent, with the low black tent of the Arabs of the hot deserts, an eastern tent. (Plate VI shows Eastern tents and homes in the Sahara.)

Children will learn much about these tents and houses of sun-dried bricks in the Scripture and history lessons. In the geography lessons they can recall these facts and notice how little life has changed (with regard to dwellings) in the East.

The tents of the *nomads* of the desert are made of woven camel-hair or goat-hair, generally black goat-hair; for they are herdsmen and keep flocks of goats and sheep. The Red Indians, being hunters, made their tents of the skins of animals they killed, especially the skin of the bison or buffalo.

Homes in the Tropics: (1) The Hot Grasslands, (2) The Hot Forests *(Plate VII)*

(1) The Hot Grasslands

Let the children have a few days to study the picture and see what they can learn from it. The well-thatched grass roof and rather open reed walls of the first house show that the climate is warm and sometimes rainy. The grass roof and reed walls also show that there must be plenty of grass and reeds about. The second house has an *overhanging* thatched roof, as though to keep off heavier rain. Some parts of the grasslands have more rain than others. Some children may have seen cottages in England with thatched roofs. Thatch keeps houses dry in the rain, cool in the hot sunshine, and warm at night. Because the houses are in grasslands the children will guess that animals can be reared. The picture shows the animals reared—humped cattle with long horns, and goats that are very like sheep, and sheep that grow hair instead of wool (see Chapter IX). These grasslands are in Nigeria.

Children, too, can see from the picture that the people who live in these houses are black people, or negroes, and the grasslands must be *hot grasslands*, because the people wear so little clothing. In these hot grasslands there are no seasons like our seasons, only a dry period and a rainy period with sunshine all the year round. Show the children where these grasslands are on the map. In Africa south of the Hot Desert (the Sahara) is a region of grassland; this region is called the Sudan. It stretches right across Africa, as the desert does, from west to east. The southern part of the Sudan has the most rain, and here the grasslands are park-like in appearance, clumps of trees appearing among the stretches of tall grasses. But going northwards across the Sudan towards the desert there is less and less rain, there are no trees, the grass becomes poorer and poorer until at last the desert is reached. The hut with the overhanging roof is in the park-like grasslands. These park-like grasslands which are common in East Africa are the land of big game—giraffes, rhinoceros, large and small antelope, lions, leopards, etc. (see Nature Study, Plate I, and Geography, Plate IX).

The wild elephants are found on the borders of the hot forests and in clearings of the forest, but very few now

remain. The children can find out or be told more about the negroes of Nigeria, and what they grow—yams, ground-nuts (also called monkey nuts or pea nuts), fruit, and grain. The negroes sell the skins of their animals for leather and their ground-nuts for making margarine and soap. White people have found out how rich their land is in ground-nuts, and how good it is for growing cotton, so railways and motor roads are being made across it.

Impress upon the children that houses vary in different parts of the Sudan as they do in different parts of England. The houses in some of the towns of the Sudan, for example the famous old town of Kano, are built of clay, a strong reddish-brown clay. There are pictures of houses in Kano, and grass houses, in *Other People's Houses* (Harrap). The children can be taught to read all the pictures in the way suggested for those on Plate VII. The reading of pictures is just as important as the reading of books. Children can easily be shown a number of pictures and learn nothing from them. It is surprising how little children learn from the pictures in their text-books. The difficulty is, of course, in selecting pictures. Some pictures teach nothing. They may give the child pleasure, but they give him also wrong impressions, and sometimes contradict the facts that a teacher is trying to impress upon the pupils!

Another point that needs emphasizing is that in the tropical, park-like grasslands the grass is *very tall*. The children often think of the grasslands as like English fields, but without hedges.

The name *savanna* given to those grasslands of Africa can be taught at the discretion of the teacher. It is a useful word, as children will need it later.

(2) The Hot Forests

Children are most interested in the tropical forests, and some teachers like to take homes in the hot forests or equatorial forests after homes in Eskimo-land, because they offer such a contrast; for example, in Eskimo-land the sun is never very high in the heavens, and for many weeks in winter is never seen at all, but in the Hot Wet Forests on and near the Equator the sun's arch is always a high one. In Eskimo-land food is scarce and has to be hunted for with difficulty; in the Hot Wet Forests, trees bearing fruit like the oil-palm can be found, and food-producing plants grow easily because of the sunshine and rain. In the hot forests, as in the hot grasslands, there are no seasons like ours. Remind the children that in the grasslands there is a dry season and a wet season, but in the hot forests there is rain all the year round; the only seasons, if they can be called seasons, are (*a*) the Time of Little Rains, (*b*) the Time of the Big Rains. Make it clear that in the time of the Big Rains it is not pouring with torrential rain for days on end; but that almost every day there is a period of hot sunshine. In the forest depths the trees and creepers are so thick that even the hot, bright light of the tropical sun cannot penetrate them except as a green gloom.

The children study the pictures on Plate VII as before. First the homes of the Pygmies, who live in the forest depths Their little huts are made of thick stems and leaves. The Pygmies are the nomads or wanderers of the

forest. The forest gives them roots, fruits of sorts, honey, game, etc., to eat. They live something like the cave-men of long ago. (See Volume II, HISTORY).

The negroes of the hot forests have settled homes. They build their huts in the forest clearings, of the products of the forest. The walls are often made of strips of bark or wood plastered with mud, and the roof is thatched with palm-leaves. The huts are sometimes round and sometimes oblong, as in the picture. In many houses the roof extends over the walls so as to form a verandah. The women work in the small gardens at the edge of the forest, where they grow bananas, yams, the manioc plant whose roots can be ground into flour, and other vegetables. Planting can go on at any time because there is always warm sunshine and rain all the year round. The men hunt in the forest or fish in the rivers, collect oil kernels from the wild oil-palm for sale, or grow cocoa-trees, as in West Africa, or other crops for sale. There are many negro villages on the banks of the great river Congo and its tributaries and in the forests along the coasts, but they all differ slightly. The people of the forests are all farmers, not herdsmen, because there is no room among the trees for grass.

In the A classes and in any good classes the children might be told that *south* of the equatorial forests in Africa there are park-like grasslands and drier grasslands similar to those of the Sudan, where the negroes live much the same kind of life. Rhodesia, for example, where white settlers are very numerous, lies mostly in the tropical grasslands. South again of the drier grasslands comes the Kalahari Desert, corresponding to the Sahara Desert. A large map of Africa (Plate VIII) is useful to show (1) the great Sahara Desert, (2) the tropical grasslands to the south of it, (3) the equatorial forests or hot forests, (4) the tropical grasslands south of the Equator, (5) the Kalahari Desert. If this map is pinned on a large blackboard, pictures of houses, people, or animals can be pinned around it. Arrows can be drawn to show the right portion of each on the map, or pieces of coloured thread and pins may be used.

Some teachers may now like to go from Africa to South America, to tell the children about another great tropical forest, the forest of the Amazon. Other teachers may prefer to leave the equatorial forests and take homes in the Southern Hemisphere, south of the hot forests.

Homes in the Southern Hemisphere

(1) *Hot grasslands* in Africa, south of the Equator. The homes here are similar to those of the hot grasslands of the Northern Hemisphere, the Sudan.

(2) *Warm temperate grasslands.* As part of South Africa is in the South Temperate Zone, it has warm temperate grasslands. The children will be interested in the grass houses of the Zulus. Pictures of Zulu houses and pictures of the grasslands of South Africa may be obtained from the Director, Publicity and Travel Bureau, South Africa House, Trafalgar Square, W.C.2. Fig. 58 shows a sketch of a Zulu village or kraal. The children can try to draw a map of this village. First there is a strong fence around it to protect it. The children will notice what good

Fig. 58.—Zulu Kraal or Village. Round Beehive-shaped Houses. Largest House is the Chief's. Windbreak in Front of Door. Enclosure for Cattle in the Centre. Fence around Village serves as Protection from Wild Animals and as Windbreak.

circles the Zulus make. It is said that the Bantu tribe to which the Zulus belong cannot draw straight lines, only curves. The largest house in the village is the chief's house. It has a windbreak round the door. The other grass houses are arranged in a semicircle around the chief's. In the middle of the kraal is a round enclosure for the cattle at night. In *Other People's Houses* (Harrap) the children will find pictures showing the clever way the Zulus build their round grass houses. A very small hole is left for a door through which the owner crawls. This description of the inside of a Zulu house is taken from *Other People's Houses*:

"If we were to peep inside when darkness has fallen and the family are at home, we should notice how stuffy and gloomy it was. The only light comes from the fire, which is placed in the centre of the floor. The smoke gets out as best it may, causing the roof and roof poles to look as black as ebony. But as the nights are cool on the plains, the family like the warmth. There is not much to see inside the huts except the family, the cooking-pots, mats of rushes for mattresses, and some weapons. But we can tell from their huts and what we see in them that the Bantus are clever at weaving mats and baskets, making clay pots, and simple weapons and tools of different kinds."

(3) *Grasslands of Australia and New Zealand.*—It is wise to introduce, if possible, Australia and New Zealand as well as South Africa during the first year's work. Children find it difficult to realize that there are civilized countries in the Southern Hemisphere where people live very much as we live. Some mention may be made of the Blackfellows of Australia with the brighter children. Their homes are the most primitive we know. They belong still to the Old Stone Age. This interests bright children especially in connection with their history. The dangers of giving lessons on the Blackfellows are (*a*) the children may think Australia is as thickly populated with Blackfellows

as Africa is with negroes. Whereas there were *never* many Blackfellows in Australia. When the Britons first settled in Australia it was a vast empty continent. (*b*) They may think that there are a great number of Blackfellows today living in their primitive homes. The number of Blackfellows compared with the size of Australia is almost negligible. The children may be interested to know why there are so few natives in Australia compared with the great number of negroes in Africa. It is because Australia was once an almost barren land, a land that had no milk-giving animals, no large meat-giving animals except the kangaroo, no beasts of burden, no cereals like wheat, maize, or rice, and no fruits or any plants of much food value, so that the poor natives had little chance of increasing in number. Their lack of food made them the most restless of all nomads. They caught fish, and the only large creatures, the kangaroo and emu, in nets. They had to live chiefly on seeds, roots, grubs and insects, and even reptiles. They are now only to be found in small numbers in Northern Territory, for they have practically all gone from Western Australia and Queensland. Today most of them live on land set aside for them by the Government or in mission stations, but, still being Stone Age people, they find it difficult to learn from the white people. It is most important for children to realize that Australia is a land of white people like Great Britain. Through the enterprise of Britons, all the good things enjoyed in Britain have been brought into the once barren lands of Australia, such as cows, sheep, horses, pigs, fowls, cereals, fruits, vegetables, etc. Anything that helps children to realize what work and effort went into the building up of the Commonwealth of Australia is worth telling. The houses described and shown to the children as characteristic of Australia should be chiefly sheep stations and farms. Interesting pictures of Australia may be obtained from 522–4, Australia House, London, W.C.2. The children will study Australia in detail in the Secondary School, but if they start with right ideas it is a great help.

New Zealand differs from Australia in having a very intelligent native race, the Maoris. It is also a more wooded and fertile land. The Maori houses are very interesting and often beautifully carved (see *Other People's Houses*, Harrap), but most of the Maoris and the Britons—whose common name is New Zealanders—live in houses very like our own, except that far more of their houses than ours are of the bungalow type—bungalows with low-pitched corrugated-iron roofs painted red or green, and each house standing completely detached from its neighbour. This description fits most of the "average" houses in New Zealand, except that in newer homes a combination of timber and brick or concrete is used, and New Zealanders are getting fond of roofs of coloured tiles. Some of the houses are very pretty with lots of bright colour about them, and each house is different from its neighbour. Stairs in a house are a curiosity. Towns are different from English towns; they look new, because of their wide straight streets, their many wooden buildings, and the shop verandahs that jut out over the footpaths. Descriptions of homes like the above will help children to get a clear picture of New Zealand. An interesting

account of New Zealand and its homes called *This Land of Ours* can be obtained from The High Commissioner for New Zealand, 415, Strand, London, W.C.2.

Let the children look at the position of New Zealand in the South Temperate Zone and compare it with the position of the British Isles in the North Temperate Zone. Quick children may see that New Zealand is warmer than the British Isles because nearer to the Tropics, otherwise its climate is much the same as ours. They may also see that in New Zealand it is *warmer in the north* than in the south.

(4) *Grasslands or pampas of South America.*—These grasslands and grassy woodlands lie south of the basin of the Amazon. Here are wheatlands, cattle ranches, and sheep. The homes of the farmers are of the bungalow type, and many are built of sun-dried bricks (or *adobe* as it is called in America) and covered with white or coloured plaster.

If time, dwellings on high mountains or plateaux may be taken: homes in the high Andes (the llama and alpaca), homes on the high table-land of Tibet (tents made of yak's hair), and the mountains of Norway, Sweden, and Switzerland.

The backward children will not be able to cover so much ground—only the most characteristic regions should be taken. Most of these regions will be found in Africa. It is probably not wise to introduce South America. Backward children will much enjoy stories from *Round the World in Stories* (Univ. London Press) in connection with their lessons on Homes. They can hear a story about the Polar Regions, the Hot Deserts, and the Arab Tents, stories of the Africans of the forest, and so on.

Some teachers may prefer to take Homes and Shelters in the second or third year, and base their scheme on *materials* used for house-building—(1) houses or shelters built mainly of grass or leaves, (2) huts and shelters built of snow, (3) tents, (4) log houses, (5) houses built of sun-dried bricks, (6) houses built of burnt bricks, and so on. This syllabus can be arranged as a kind of project. Such a course needs more thought and is most suitable for the upper classes who know their way about the world fairly well. It makes a good revision course.

Pictures of almost every type of house, and descriptions of almost every kind of building material, will be found in *Other People's Houses* (Harrap). It is a useful book for carrying out the above scheme, and is simply written so that children can consult it for themselves, and will enjoy studying the pictures. Copies should also be placed in the classroom libraries of the upper classes, so that they can revise their first year's work and use the pictures and information in connection with the new work.

Stories of Animal Life

Backward and dull children will enjoy some stories of animal life. The stories and descriptions of animals can be used in the reading lessons. Combining the English and geography sometimes means that slow children are not worried by too many ideas and can concentrate on a smaller vocabulary. In Volume I, ENGLISH, methods of teaching reading to backward readers, based on topics of interest, are discussed. Lions and tigers are obviously

topics of interest and work in well with the nature-study lessons (see the first year's work in Volume IV, NATURE STUDY), also through such stories of animals the children become familiar with the different regions of the world. The following is a suggested syllabus; some of it will fit in with a course on "Other People's Houses."

(1) CREATURES OF THE HOT LANDS OR TROPICS

(*a*) India is the home of the *tiger* and the *leopard* (NATURE STUDY, Plate I), of the royal elephant, smaller of ear and far more docile and wise than its great cousin of Africa; the home, too, of Meg the Cobra (see Volume IV, NATURE STUDY), and the gallant little Riki-tiki-tavi, the mongoose, the hereditary foe of Meg the Cobra, between whom there is constant warfare. All Junior children should read or have read to them Rudyard Kipling's story of Riki-tiki-tavi.

The tiger is lord of the jungle throughout India and the greater part of Asia. Wherever large tracts of forest and jungle abound, there the tiger is certain to be found, for he dislikes the burning rays of the hot sun. His striped coat makes him difficult to be seen in the jungle.

(*b*) The hot grasslands of Africa are the home of the lion, leopard, antelope, wildebeest, zebra, and giraffe (Plate IX). Some account of these animals will give the children a better background for the homes of the negroes of these lands and help them to picture the park-like grasslands, the grasslands nearest to the forests. The high grass of these lands sometimes hides the animals from view. Here and there are clumps of low trees that remind one of umbrellas, because they spread out so at the top. This is where giraffes and zebras love to feed, because their colour is so much like that of the tall grasses and low trees that it is hard for their enemies to see them from a distance. During the dry season, the longest part of the year, the animals visit water-holes to drink, especially at night when they cannot be seen. Lions often hide near water-holes in order to spring upon antelopes when they come to drink. As soon as the lion has eaten what he wants, hyenas and jackals feast upon the remains. Lions like the open rolling plains because of the herds of antelope, giraffe, and zebra that feed there.

The leopard or panther is to be found throughout Africa from Algeria and Egypt southwards to Cape Colony. Although he hunts the herds of game as the lion does, he is more cat-like in his habits and more cautious. He likes the more wooded country, and places where tall reeds and bushes afford shelter and hiding-places in which he can lurk and stalk his prey.

The African grasslands are the head-quarters of the antelopes, for nowhere else, the whole wide world over, are there so many kinds to be found. Antelopes are ruminants (see Volume IV, NATURE STUDY); they resemble cattle and goats in having horns that are *not* shed annually as the horns of deer are. The antelopes therefore belong to the cattle family. The African antelopes vary in size. There is the tiny royal antelope no bigger than a rabbit, the gentle gazelles, and antelopes varying in appearance and size up to the magnificent eland that stands six feet high to the shoulder. The gnus or wildebeest are very like a horse in

build. In spite of their rather ugly heavy head, they are wonderfully active. Once vast numbers of antelopes roamed the grasslands, but because of the coming of so many professional hunters to Africa, their numbers have been sadly reduced. In Kruger's National Park in South Africa many of these graceful antelopes are to be seen. Booklets containing descriptions of this huge Park or reservation where the wild animals of Africa live in their natural surroundings, and fine pictures of animals, can be obtained from the High Commissioner, South Africa House, Trafalgar Square, W.C.2.

A few wild elephants still remain in Africa. They are the biggest four-legged creatures existing today. The African elephant is easily distinguished from the smaller Indian elephant by the enormous size of its ears, which when erect stand out from the sides of its head like a pair of leathery wings; it is also much more difficult to tame than the Indian elephant. Every year this magnificent animal is becoming rarer. Its natural haunts are in the forest districts south of the Sahara, but a few remain under protection in South Africa.

Then there is the rhinoceros, the great old hippopotamus who has his home in the lakes and rivers south of the Sahara (these animals, like the elephant, are becoming rarer every year), and the baboons and chimpanzees of the forests.

Children are always interested in the creatures of Africa because of their variety and, in many cases, because of their beauty. Talks about these animals give children some idea of the climate and the various types of vegetation in Africa.

To complete the picture of animal life in Africa the children will hear something about the camels and goats of the Sahara in connection with the tents or homes of the wandering Arabs or Bedouins.

(2) Creatures of the North Polar Region (see Plate V)

The Polar bear, seal, Eskimo dog, caribou and reindeer, etc.

(3) Creatures of the South Polar Region

The penguins. Lessons on the penguins are valuable because they help children to realize that there are no human beings in the Antarctic, and to understand the difference between the North and South Polar Regions.

(4) Creatures of the North and South Temperate Regions

(*a*) The northern lynx (see Nature Study, Plate I), whose home is the forests of Scandinavia, Siberia, Northern Siberia, Northern Asia, and North America, very valuable for its fur, and other furry animals of the cool forests; for example, the red squirrel of the British Isles, the grey squirrels of the Siberian forests, the chipmunks and bears of North America (Plate XVII). Wolves are found in many parts of Europe, Asia, and North America, and so on.

(*b*) In the South Temperate lands the llamas and alpacas of the Andes are of interest and some importance (see Plate XVI).

In lessons about the creatures of North and South America, the children are interested to know that there are no lions or tigers there.

The *cat family* (see Volume IV, NATURE STUDY, first year's work) is represented by (1) the *jaguar*, which exceeds the leopard in size and beauty of coat. Its home is in Central and South America as far as Patagonia; (2) the *puma*, sometimes called the American lion because of its uniformly tawny coat; it ranges from British Columbia on the Pacific to the New England States on the Atlantic almost as far south as Cape Horn; (3) smaller animals like the *lynx* which has already been mentioned.

Children who have learnt about homes or shelters in the forests of the Amazon will be interested to know something about animal life there, the various kinds of monkeys, strange birds like the toucan, lovely birds like the humming-birds, and alligators (caimans); the biggest snake in the world, the anaconda, lives in the swamps of the Amazon basin. Teachers will find these books useful: *The Naturalist on the Amazons*, by Henry Walter Bates (Dent's Everyman Series). This book is full of descriptions of the forest, the forest Indians, their homes, occupations and amusements, and particularly the wonders of bird and animal life in the forest. Another book that will be much enjoyed by the teacher (passages, if edited, can be read to the children) is *The Sea and the Jungle*, by H. M. Tomlinson (Duckworth).

Activities and Projects

Many activities are possible in connection with the above scheme.

(1) Children will enjoy looking at the pictures in natural-history books to find out more about the different animals and creatures they meet in their study of other people's houses or animals. They like to find the names of new animals not mentioned by the teacher; for example, they may want to know about the gorilla and where he lives, and so on. Useful books from a shilling upwards can be obtained from The Public Relations Department, The Zoological Society, Regent's Park, N.W.8; for example, *Life Story of King Penguin*. Children can make zoo books for themselves in which they put the animals that most interest them.

(2) They use the map of Africa (Plate VIII) and a large map of the world to show where certain well-known animals live. This can be done by pasting or pinning little pictures around the outside of the map, as already described for houses.

(3) They collect pictures of as many animals as possible and arrange them in different ways; for example, they put all the pictures of wild animals found in Europe together, and so on. They try to make a complete collection. Class books are also made, labelled (*a*) Europe; (*b*) India and other parts of Asia; (*c*) North America; (*d*) South America; (*e*) Australia and New Zealand. These books are filled up by degrees and are a source of great pleasure and interest.

Lucky children who live in London will be able to visit the Zoo and see with their own eyes some of the strange creatures they hear about or read about. In many towns there are also zoos, and travelling menageries visit country places at times.

Country children will enjoy making a list of all the creatures that live in a nearby wood or fields or moors. This can be done in connection with their nature study.

As many books as possible dealing with wild life should be accessible to the children in the class and school library. Free Libraries, too, especially some Free Libraries, are a great help. Many good books about the Zoo and its inmates are published from time to time, some descriptive and some stories. A good story-book useful from the point of view of geography is *Story Time in the Zoo,* Heritage of Literature Series (Longmans).

(4) Many projects arise in connection with "homes," both homes of people and of animals. Easy projects for seven- and eight-year-olds will be found in *Projects for the Junior School,* Book I (Harrap).

Many children are interested in bricks and brick-making, and how the bricklayer builds a wall. They can experiment with home-made bricks; some may want to find out about slate or concrete, and so on. Many useful booklets will be made by children on topics that interest them. Very keen children will want to collect specimens of "rocks" used in house-building. This can be done during nature rambles, geographical expeditions, and in holiday-times. The specimens will include (1) brick earth or clay; (2) chalk; (3) sand; (4) slate; (5) sandstone; (6) limestone; (7) granite. They will be interested to know about the hard rocks and soil in different parts of Britain, that the Wye Valley is carved out of old red sandstone, and the rocks on each side of the Avon Gorge are limestone, and so on (see Plate IV).

A large class picture-book should be made for the best drawings of homes in other lands, so that a complete record is kept of the homes studied and their exact position. In some cases the route to them from the British Isles by sea or air can be found out and written also in these books.

Collecting or drawing pictures of different kinds of houses in their neighbourhood—for example, flats, bungalows, etc—and also houses in different parts of the British Isles, appeals to many children and is well worth while —guide-books will help them. They can find brick houses in London, stone houses in Plymouth, granite houses in Aberdeen, slate-roofed cottages in Wales, and so on. This project can be carried out best, perhaps, in connection with the fourth year's work, the British Isles.

Many children, especially boys, are interested in the building of houses and enjoy watching men at work and talking about what they see. A simple project on "Building a House" will be found in *Projects for the Junior School,* Book III, Chapter I (Harrap).

CHAPTER EIGHT

REGIONAL GEOGRAPHY FOR THE SECOND YEAR

HOME geography will continue, and where possible it will be closely linked with nature study. There will be visits to places of geographical interest, and further stages in map work. With good classes the large-scale Ordnance Survey Map may be introduced (see Chapter V). Certain special studies as suggested in Chapters V and VI may be taken—hills, valleys, rivers, quarries, soil, the seaside, etc., and local industries that will fit in with the scheme suggested for this year: "What the World Eats," such as farming, market gardening, ships and their cargoes, etc. Much will depend on the locality of the school. Rural schools will give most attention to the crops grown, seed-time and harvest-time, the nature of the soil, etc.; town schools will deal with manufactures, docks, roadways, and railways, etc., depending on their position Clearly a topic such as "What the World Eats" can be easily linked up with local or home geography. Regional and world geography will also be closely interlocked.

"What the World Eats" covers so much ground that the teacher must select, with as far as possible the help of the children, the foods to be discussed. A great deal of ground can, however, be covered in A classes, because children are often so interested in food that they like to read and find out information for themselves from shops, advertisements, books, etc. The topics, too, will link up with their study of homes in the first year. They also link up with their history, for a large part of history is concerned with how people obtained food and cooked it. The children can at fitting times be reminded of their lessons on the cave-men, the wandering herdsmen, the growing of corn in Egypt, and of how the Greeks traded their olive oil and wine, and founded colonies to get food, and so on (see Volume II, HISTORY).

It is well to point out to children—though intelligent ones may see it for themselves as each topic develops—the enormous amount of work and the number of people necessary to provide the world with food. Also the great variety of food today compared with food of long ago. Some children will realize how much time their mothers have to spend on buying, preparing, and cooking food, etc. Every meal we eat has been brought to us by much labour from many parts of the world. Let the children make a list of the foods they usually have for breakfast in their part of the world, say England, thus: *tea, coffee,* or *cocoa, milk, eggs, bacon, porridge, bread, butter, marmalade.* The teacher writes by each the place from which it may have come, thus: *tea,*

Ceylon or India; *coffee,* Brazil; *cocoa,* West Indies; *milk,* home farms; *eggs,* Ireland; *bacon,* Denmark; *porridge,* oats, Scotland; *bread,* wheat, Canada; *butter,* New Zealand; *marmalade,* Scotland. Many teachers base their series of lessons or syllabus on a typical meal, either breakfast or dinner; others make the grocer's shop a starting-point.

But these methods of selection are on the whole too arbitrary, and they may not allow the teacher to include the regions of the world she wishes. "Things Seen in Shop Windows" gives one the freest choice to travel from Pole to Equator, and from Equator to Pole.

But one needs to select material that will work in reasonably well with the first year's work and help to revise and amplify it. Opportunities for the children to link the first year's work with the second encourage thought. The right association of ideas is thought. Too often our syllabuses are not planned to give the children opportunities for constructive thinking. Little reference is made to last year's work, or else there is tiresome repetition; for example, when a child has to do the same year's work again. A child cannot think to advantage without knowledge, but opportunities must be made for him to use his knowledge, otherwise it is lost. The thoughtful linking of new facts with old is especially stressed in Volume II, History.

Selections can be made from the following eight headings, the teacher choosing those that fit in with the locality of the school and the first year's work.

(1) *Fruits.* (*a*) Temperate lands. *Fruits of the Rose Family*—apples, quinces, peaches, plums, cherries, apricots, blackberries, raspberries, all belong to the Rose Family (Plate XIV, Nature Study and Simple Science). This topic fits in well with nature study, home geography, and the first year's work in geography; for example, homes in the South Temperate Lands, New Zealand apples, or with North Temperate Lands, Canadian apples. (*b*) Sub-tropical, dates—the Sahara and the Land of the Two Rivers. This links up with the history lessons (see Volume II) and with the first year's geography, the tent-dwellers and oases of the Sahara. (*c*) Tropical lands, bananas and perhaps pine-apples. Bananas take the children back again to the hot forests, the homes of the negroes and pygmies. (*d*) *Fruits of the Citrus Family,* oranges, lemons, etc., and dried fruits such as currants, sultanas, etc., are perhaps better left for the third or fourth year, as they introduce the children to the Mediterranean type of climate. However, they may have to be touched upon, as children are eager to make a complete list of fruits and the countries most famous for them.

(2) *Grains.* Food from the Grain Family, or the Corn Family. Again, this is a link with first year's geography, local geography, nature study, and history. (Corn in Egypt [Chart II History].)

(3) *Vegetables.* Mainly local geography and nature study.

(4) *Food from the sea.* Herring fishing and deep-sea fishing. This anticipates a more detailed study of the British Isles and can, if desired, be taken in the fourth year.

(5) *Oils* from fruits and nuts for margarine—the oil palm, coconut palm,

ground-nuts; the olive tree might also be taken.

(6) (*a*) *Dairy produce.* Milk, butter, eggs, bacon. Milk is dealt with in Volume IV, NATURE STUDY. Dairy farming can be considered in the fourth year in connection with the detailed study of the British Isles. (*b*) Beef and Mutton. This topic will take the children to the temperate grasslands again—the prairies of North America, the pampas of South America, etc. It links up with the fourth year's work in nature study, farm animals, and with fourth year's geography.

(7) *Pleasant drinks: water, cocoa, tea, coffee.* Water perhaps should be left to the fourth year, when reservoirs, etc., can be dealt with in connection with the British Isles. Some ideas, however, about their water-supply will be gained by the children through their studies in local geography.

(8) *Sugar, cane sugar, beet,* etc., *spices, salt.*

Such a syllabus, based as "Foods," lends itself to many activities on the part of the children. Some of these activities the children will think of themselves, some activities may have to be suggested by the teacher, but children are always eager to hear about ways of learning other than reading from books.

Here are Some Suggestions for Activities

(1) Plant a garden; a box is better than no garden. Grow in it as many kinds of food as there is room for. There is generally room somewhere for mustard and cress. Watch the plants grow from seeds. Watch the foods ripen. Serve them at your dinner-table at school.

(2) Make collections of foods of different kinds, using real specimens or pictures. Plan with your friends exhibits of (*a*) fruits, (*b*) vegetables, (*c*) nuts.

(3) Draw pictures of foods of different kinds. Fruits and vegetables are interesting to draw. Have an exhibition of your pictures.

(4) Magazines and newspapers generally have pictures of food. Cut out some of these pictures and paste them in a scrap-book. You can find pictures about biscuits, cereals, meat extracts (Oxo, etc.), preserves, and so on. Arrange your pictures under headings; for example, keep all the jams or preserves together, the cereals together, and so on. If possible, say from where each comes; for example, biscuits from Reading, jam from Kent or Essex, and so on.

(5) Make a collection of wrappers or labels from tins of fruit, fish, vegetables, meats, etc. Your mother will help you. From the wrappers you can tell where the food was tinned (or canned as they say in the New World). See from how many different countries or places you can find wrappers. Enter your finds in a note-book. Under Fish you might have sardines from Portugal, silts from Norway, etc. Under Meat there may be stewed steak from the United States, tongue from the Argentine, and so on.

(6) Find pictures, or draw pictures, of lorries, trucks, trains, and ships, etc., that carry food. If you cannot find pictures, or draw, write the names of all conveyances you have seen or heard about, with a short description, as, milk-train, vegetable cart, potato lorry, fishing-boats (trawlers, etc.), grocery van, etc.

(7) Collect stories and poems about food. You will find several in *A Tale in Everything* (Univ. London Press).

(8) When you are riding in the train or going on a trip, find out, by keeping your eyes open, as many things about food as you can. Some of the facts you learn you can add to your various booklets or collections. Write stories about what you see; for example, " A Visit to a Market," "A Day in the Country," "Food I Saw from the Train Window," " What I Saw at the Fish Shop." Make interesting lists of what you see, as " Food Carts I Saw from My Window " (milk-cart or electric trolley, bread van, and so on), " What I Saw in the Grocer's Window."

(9) Make a list of countries with the help of your atlas. By the side of each country put the name of some food or foods it is famous for or produces, as: *Ireland,* bacon, butter, eggs; *Denmark,* bacon, butter, eggs; *Portugal,* sardines; *Greece,* currants; *Spain,* oranges, and so on. You will have to complete your list by degrees as you learn more geography or find out more facts for yourself.

Other interesting projects in connection with food will be found in *Projects for the Junior School,* Books I–IV (Harrap); for example, " Dinner-time Round the World " (Book I), " Good Things to Eat " (Book II), " The Plum Pudding " and "The Grocer's Shop " (Book IV).

Some Material and Suggestions for carrying out the above Syllabus

Teachers will find most of the material they need in *What the World Eats* (Evans Brothers, Ltd.). This book can also be used by the pupils. There should be several in their classroom for them to consult. The large pictures and maps are very helpful and can be used in a variety of ways. There are also suggestions for things to do, so that they can be used for individual work.

(1) (*a*) *Fruits of the Rose Family* (Plate XIV, NATURE STUDY AND SIMPLE SCIENCE). The children themselves can tell a great deal about these fruits. They may have seen apple orchards or been blackberry-picking. Get from them first all they know. Town children will tell about the fruits of the Rose Family they have seen in shop windows. They can also tell what they have learnt about them in the nature-study lessons. They know that some grow on bushes and some on trees. Each child can choose a fruit to write or tell about. Many children will like to make booklets about fruits of the Rose Family in which they mount pictures and write short descriptions. When enough information has been collected, let the children travel about the world finding countries famous for apples and pears. They can begin at home and find places in Britain where apples grow well: Devonshire and Hereford. Their travels will take them about the North Temperate Lands and the South Temperate Lands. In the north to Europe (France and Germany), to Canada, to the United States (especially California, which is the greatest apple-growing country in the world). In the South Temperate Lands to the southern part of South Africa, to Australia, to New Zealand. Their travels make the children familiar with some of the most important countries in the Temperate Zones.

(*b*) *Dates,* the products of the oases of the Sahara desert and the valley of the Tigris and Euphrates. The largest date-groves in the world are near Basra

in Iraq, on the banks of the river formed by the confluence of the Tigris and Euphrates. Leading into the date-groves from the river are hundreds of canals and ditches which twice a day are flooded by the tide from the Persian Gulf pushing back the fresh water of the river and making it deep enough to enter the canals and bring drink to the date-palms. Remind the children of how Hammurabi and other great rulers dug canals (see Volume II, HISTORY). Britain gets most of her dates from Iraq (this can be verified by the children if they inquire at grocers' shops), but some supplies come from North African oases by way of Algiers, Tunis, and France.

To the desert dwellers (see first year's work) the date-palm gives many things besides food—its leaves provide thatch, mats, and baskets; from its fibres cords are made and tow for stuffing saddles; leaf-stalks make sticks, and the stub-like ends are useful for fires, for they give out great heat. The timber of trees too old to bear much fruit is used for building. The framework of the doors and the doors themselves in the sun-dried brick houses of the oases are made of this wood. This helps to recall their first year's work to the children.

(c) *Bananas.* These take children back to the tropical forests, the forests of the Congo where the negroes and pygmies live. But the children will want to know whence the bananas come that they eat. The British Isles get their bananas from the tropical lands of the West Indies, especially Jamaica. Large quantities also come from the warm Canary Islands which do *not* lie within the tropics. Because of careful cultivation, small but excellent bananas can be grown in the Canaries.

The children will find some interesting facts about bananas in *What the World Eats* (Evans); for example, "Harvesting the Banana," the travels of the banana plant from Southern Asia, its original home, to Africa, the Canary Isles, the West Indies, and the New World. Plate XIII shows the harvesting of the banana. The banana plant is not a tree, although some kinds grow to more than twice the height of a tall man. It is a species of lily and its "trunk" is really a compact mass of overlapping leaf-sheaths. Each plant or "tree" has one long thick stalk on which grow the fat purple flowers that change to clusters of bananas called "hands" (a "hand" is a cluster of bananas, which stick out like fingers on a section of the fruit stalk, Plate XIII).

The flowers of the banana plant are produced in clusters, spirally arranged upon their long stalk. The first few of these clusters which appear give rise to the future "hands" of fruit. The clusters towards the end of the stalk are sterile flowers incapable of producing fruits. The children can see the empty part of the stalk on Plate XIII; the flowers have dropped off. The stalk ends in a more or less heart-shaped or conical bud or "blossom" composed of maroon-coloured bracts, tightly enclosing a cluster of flowers.

Each plant bears a "single bunch" of bananas like that in Plate XIII. It is made up of from six to nine "hands" or clusters. Each "hand" contains from ten to twenty (usually sixteen) bananas or "fingers." The children may be able to see a "hand" of bananas if they visit a fruit shop. They can learn about the banana flower and fruit in the nature study lesson. A very

interesting booklet called *The Story of the Banana* may be obtained from the Educational Department, United Fruit Company, Boston, Massachusetts. Most of the bananas that appear in shops and barrows in Britain have been bought from the United Fruit Company, which buys them from the growers. One very large estate company in Jamaica produces over 50 million bananas yearly. The banana tastes best and is most valuable as a food when it is harvested green and allowed to ripen off the plant.

Bananas and dates are two very popular fruits from the Hot Lands. A third popular fruit is the pine-apple. Children again can read about these for themselves in *What the World Eats* (Evans); in this book they will see the strange way in which pine-apples are planted in Hawaii. As the pine-apple is not nearly as important a food product as the banana, it can be omitted from the syllabus if necessary.

The Grass Family or Corn Family *(Plate X)*

This is an interesting and important topic. Most of the people of the world eat bread of one kind or another, for it is man's main food, and the greater part of the world's bread is made from the grains of different grasses.

These grasses, once wild and small-seeded (see Volume II, History), have through countless centuries of cultivation become the *cereals* of today; they have become tall, heavy-seeded, and rich in food for man and beast. It must be explained to the children how the grains got the name of cereals. They were called after Ceres, the goddess of Corn, worshipped by the Romans.

The cereals of cool temperate lands are *wheat, oats, barley,* and *rye;* those of warm temperate and tropical lands are *maize* (Indian corn), *millets, rice,* and *wheat* (wheat is grown in the cooler seasons in certain tropical lands, as India).

In the Old World corn is the family name of all the cereal plants. Cornfields mean fields of wheat, barley, or oats; but since wheat is so important, when corn is mentioned it generally means wheat. In the New World, America, the word *corn* means only Indian corn or maize. We use the word *corn* for maize in the word *cornflour,* which means flour made from maize or Indian corn. This is often confusing to children. An interesting story that helps younger children to remember the Corn Family and that maize in America bears the family name of corn will be found in *A Tale in Everything* (Univ. London Press).

Begin with the story of wheat. The children will have learnt something about wheat in their history lessons (see Volume II). It was grown by man in prehistoric days. The children will soon see that all the great wheatlands of the world are in temperate lands. Wheat needs moisture and cool weather during the early growing period (spring in Britain); then warm and bright sunny weather when the heads have formed (summer), a little more moisture to swell the grain before it ripens (summer); and finally a bright sunny period for the harvest (autumn). Although wheat is mainly grown in the temperate lands, a great deal is also grown in India and other hot lands where it is a cool-season crop. It is sown after the rains, grows during the cooler season, and is harvested before the hot season sets in. This is probably

too difficult for young children, who do not yet understand the three seasons in India—hot season, rains, cool season. But intelligent children may want to know how wheat can be grown in India. Different climates and soils produce different kinds of wheat. Wheat grown in warm, dry countries has small, hard grains useful for making macaroni, vermicelli, spaghetti, and semolina. This small, hard wheat is called "hard wheat."

Wheat is one of the *giant crops* of the world and grows in so many different countries that there are wheat harvests in every month of the year, as this table shows:

January harvests are being reaped in Australia, New Zealand, and Chile; in *February* and *March* there are harvests in India and Upper Egypt; in *April* Mexico, Lower Egypt, and south-western Asia (Syria and Persia) have their harvests; in *May* Morocco, Algeria, Tunis (north-western Africa), and northern China; *in June* Spain, southern France, Italy, Turkey, California, and Virginia; in *July* France, Austria, Hungary, Southern U.S.S.R., and the United States; *in August* Britain, Canada, northern United States, Germany, Netherlands, Belgium; in *September* and *October* northern U.S.S.R., Scotland, Sweden, Norway, in *November* South Africa and the Argentina; in *December* Argentina, Australia.

The six greatest wheat-growers in the world are the United States, the U.S.S.R., Canada, India, France, and Argentina. (These should be verified in Whitaker.) The six greatest exporters of wheat are, in order, Canada, the United States, Argentina, Australia, India, and Russia (this should also be verified from time to time. India and Russia need a great deal of wheat for their own people). Canada exports a great deal of wheat to Britain. Europe may be called the "wheat continent" because, although there are actually fewer acres under cultivation than in the New World, they yield better crops. The two countries in Europe that generally produce the most wheat are France and Italy (one remembers how fond the Italian people are of macaroni and spaghetti).

The British Isles are the world's biggest buyers of wheat. They buy mostly from Canada, Australia, Argentina, the United States, and a little from India and Egypt.

Just how many of the facts given above should be told to the children depends on their age and ability. If this syllabus is used in the fourth year, the children will have had enough experience to appreciate many of these facts. They will enjoy finding on the globe and map the countries that have harvests in January, February, and so on, and seeing in some cases the reason for the different times of the harvests.

With the younger children, the second year, the lessons will begin with the cornfields they know. Country children will be more or less familiar with the processes of planting and harvesting wheat, town children will need more descriptive matter and explanations. When they have told all that they know, let them imagine they are in the newer wheatlands of Canada, the United States, or Australia. These are very different from the wheatfields of Europe because they are so large. Land is cheaper in the New World, so it pays to cultivate huge fields rather than concentrate on getting

a good wheat crop from a small field.

Take some particular wheatfields for the children to visit, and let them find them on the map; for example, they can visit the prairie provinces of Saskatchewan, Alberta, and Manitoba in Canada. Explain that the cornfields of North America were once the prairies where the Red Indians lived a wandering life hunting for game, and moving from place to place with their wigwams. The children have heard about the temperate grasslands in the first year.

Planting Wheat

The children's own experiences in tending their little gardens will help them to understand. Refer to the digging, raking, and planting they have done in play or in earnest. First the ground has to be dug up. Instead of using a spade, a farmer uses a plough pulled by horses or by a tractor (some children may be able to tell about ploughs they have seen). As the plough is pulled across the field, it cuts out a strip of soil and turns it upside down at one side. The little ditch or track that the plough cuts is called a *furrow*. Each time the plough goes across the field it makes a new furrow. The soil cut from each furrow is turned over into the furrow made the time before.

Perhaps the ploughs the children have seen make only one furrow at a time. Remind them that on the great wheat farms they are visiting, the farmer uses *gang ploughs*. These cut several furrows at once. Sometimes gang ploughs cut as many as twelve furrows at once.

Next the ground has to be smoothed or raked. Instead of using a rake, the farmer uses a *harrow*. The harrows are big machines that are used after the ploughing is finished. They are often pulled by tractors, too. They work just as a huge rake would. Some harrows have teeth and some have little sharp wheels or discs, disc harrows. Harrows are pulled back and forth over a field until all the ground is soft and fine, and ready for the wheat seeds.

The farmer does not plant wheat seeds or grains by hand. He uses a machine called a drill to sow the seed. It has a long box fastened between wheels. There are small holes in the bottom of the box. Little tubes go down from the holes, and the seeds drop through them to the ground. In front of each tube is a tiny shovel that digs a furrow as the machine moves along. Behind each little drill or shovel, the seeds keep dropping into the furrow. The earth from each side slides back into the furrow and covers the seeds.

A tractor or motor sometimes pulls two or three drills so that a strip of ground thirty or more feet wide is sowed each time the seed-drill goes across the field. When the wheat is planted the farmer has to wait for the sunshine and rain to make it grow. Usually he does not water it. In some parts of the country, where there is little or no rain, long ditches bring water from a lake, river, or reservoir. In these ditches there are gates, which hold the water back until the farmer is ready for it. Whenever the plants need water, he opens the gates and lets the water flood the grainfields. (The children have learnt in their history lessons how the Egyptians watered their cornfields with the help of the river

Nile and canals. It will stir their imagination if they compare the primitive ways of ploughing and sowing described in Volume I, HISTORY, with the wonderful machines of today.) In their nature lessons they learn about the growing of seeds and watch seeds grow.

Harvesting

Harvesting in Canada is a wonderful sight. The golden grain seems to cover the whole earth, and in every direction there is nothing to be seen but wheat, wheat, wheat, until miles away in the distance the blue sky seems to come down to meet the golden fields. The farm buildings with their trees around them look like little islands in the ocean of wheat.

When it is time to cut the wheat the farmer uses machines. On the smaller farms clever machines called *binders* are used to cut and bind the wheat, just as they are used in Britain. These are drawn by big teams of horses or more often by motor engines. On one part of the binder are moving knives that cut off the wheat-stalks not far above the ground. They fall on a platform. On the platform is a wide moving belt made of canvas which carries the wheat up into another part of the machine. There the stalks are packed into a bundle with the heads all pointing the same way. As each bundle gets to be the right size, iron fingers tie a string around it. As the machine goes through the field, these bundles or sheaves are dropped off, a few at a time. Men who follow along behind the binders set the bundles up into *shocks, stooks,* or *stacks* (different names are used in different parts of the world). The men are careful to set the bundles with the heads up so that they are in the sun.

Threshing

The shocks are not left in the fields very long. The farmer is anxious to get the wheat seeds or grains out of the heads as soon as possible. To do this he uses a threshing machine, steam-driven or motor-driven. As each bundle of wheat goes into the machine, the string that held it together is cut. In the first part of the machine the seeds are beaten out of the heads. In the next part they are separated from the husks and stalks. Then the seeds are sifted several times to get rid of all the straw, and finally run out of the machine through a tube, where men catch them in bags. The stalks (or straw) are blown out of the threshing machine and piled on the ground. Remind the children that if they are in the country at threshing-time they may see this yellow straw blowing out, looking from a distance like a cloud of yellow dust.

GREAT MACHINES CALLED COMBINES

On the largest farms of Canada (and, of course, the U.S.A.) still more wonderful machines are used called *combines*, or harvest threshers. These are reapers and threshers all in one. They are pulled through the fields by tractors or by many horses. The combine first cuts the heads off the wheat. These fall on a platform and a belt carries them up into the machine. Then steel fingers, that work much faster than man's fingers can work, knock the grains out of the heads. Machinery pours the grains into sacks, sews up the sacks, and drops them into wagons. It would take a great many men to do the work that one combine does.

AFTER THE HARVEST

The farmer uses both the wheat seeds and the wheat straws. He uses the grains or seeds in three ways: (1) some he keeps for planting next year, (2) some he uses to feed farm animals, (3) but *most* of his grain he sells for making bread and providing food for people. The farmer may use some of the straw (the old stems and leaves, etc., of wheat) for spreading on the floors of his sheds for his animals, but a great deal of the straw is burnt on the prairies and ploughed into the earth again.

The story of the journey of wheat from Canada to Britain and other places is full of interest and of great importance from the point of view of teaching geography.

Travels of Wheat from the Prairies of Alberta and Saskatchewan to Britain *(Plate XI)*

When the farmers have threshed their wheat they send it by motor truck to tall grain stores or granaries called *elevators.* These grain elevators (picture 1 on Plate XI) are dotted along the railways throughout the grain country. Here the wheat is stored ready for the grain train. The trains for moving wheat are enormous. Those going east frequently have eighty cars behind a single engine. The grain trains are filled by allowing the grain to pour from chutes or pipes in the elevator. The greater part of the wheat travels *eastwards* via Winnipeg, a great wheat-collecting and trading centre, to Port Arthur or nearby Fort William on Lake Superior. Here it is stored in much bigger elevators called terminal elevators (picture 2, Plate XI). The wheat is unloaded at the part of the elevator marked A by means of suction pipes. Some of these terminal elevators hold 2,500,000 bushels. Inside the elevators are grain conveyors or moving belts which carry the grain to any part of the elevator. At B (picture 2, Plate XI) the big grain boats or lake freighters are loaded. The grain boats are rather like overgrown barges, for they are often twice the length of a football pitch.

Picture 3, Plate XI, shows a lake freighter being loaded from a terminal elevator. The flow of the wheat from the discharge pipe or chute can be clearly seen. Before closing up the hold the grain has to be levelled off. Men can be seen doing this in picture 4, Plate XI. Notice the kind of mask they use over their mouth and nose because of the dust. Picture 5 shows the laden lake freighter on its way across the lake. Notice the long hold. This freighter is 633 feet long.

The Voyages of the Lake Freighters from Port Arthur or Fort William

Let the children find and talk about the Great Lakes, Lake Superior, Lake Huron, Lake Erie, and Lake Ontario, and notice where they are joined to each other by canals.

(1) Some lake freighters go across Lake Superior, Lake Huron, Lake Erie, Lake Ontario, down the St. Lawrence to the great port of Montreal, where they are unloaded. The grain is taken out of the hold by suction pipes. From Montreal, *in the warm months,* ocean-going steamers take the grain to Britain and Western Europe.

(2) Some big freighters unload at ports on the lakes, at (*a*) *Buffalo* on Lake Erie; from Buffalo the grain goes

by train to the ports of New York and Montreal; (*b*) Kingston on the St. Lawrence and by train to Montreal; (*c*) ports on Georgian Bay in Lake Huron, from whence it is sent to Montreal by rail. All the above routes make use of the Great Lakes and carry the grain *eastwards*.

The Travels of the Grain Westwards

Let the children notice how near Saskatchewan and Alberta are to the west coast. A good deal of wheat from these provinces goes westwards by train to the famous port of Vancouver. Mountains have been levelled and others tunnelled to make easy the pathway to the Pacific ports. The children will notice the mountain barrier between the plains and the Pacific. From Vancouver loaded vessels find their way to Britain and Europe via the Panama Canal, and to the Far East. Besides Vancouver there is another port on the Pacific coast that ships wheat, though not nearly as much as Vancouver, namely, Prince Rupert.

The children will notice what a *long sea voyage* it is from Vancouver to Great Britain. Yet it is cheaper than sending wheat via New York or Montreal, because the railway journey is shorter; sending wheat by rail is much more expensive than sending it by water.

Intelligent children may be interested in learning about a third export route, the *shortest route* from the prairies to Britain. This has been used since 1931. The wheat goes by train to Churchill on Hudson Bay and then by ocean-going steamer to Liverpool. It is not easy on a flat map for children to see the advantage of this route, but the globe will show them that it is much shorter than any other. From the wheatfields to Liverpool is some 1,000 miles shorter by the Hudson Bay route than by the Montreal route. But the Hudson Bay route has one serious disadvantage. It is ice-bound for the greater part of the year, and is only open for shipping for about two or three months in the summer. This helps children to realize the winter coldness of so much of North America. Even in the summer months icebergs are a trouble. Thus this newer route is not of great importance yet.

Icebergs are also a danger off the St. Lawrence estuary (sinking of *Titanic*, 1912). The waterways of the Great Lakes and the St. Lawrence are closed from about the first week of December until April.

The great wheat-exporting ports for Canada are, clearly, *Vancouver* (perhaps the greatest), *Montreal*, and *New York*. In winter Halifax (Nova Scotia) and St. John (New Brunswick) export from Montreal elevators. Children find these ports on their atlas maps.

Naturally the Prairie Provinces with their miles of wheatlands and pastures are not a region of great towns. Winnipeg, the capital of Manitoba, is the largest city and a great collecting centre for wheat, from which it goes by train to the Great Lakes and the eastern or western seaboards. Other market towns are Edmonton (capital of Alberta) and Regina (capital of Saskatchewan)

Children who remember learning about "Other People's Houses" in the first year, and are still adding to their books about "Houses Near and Far," will like to draw a typical home and barns on the Canadian wheatlands for their books (Fig. 59). The children

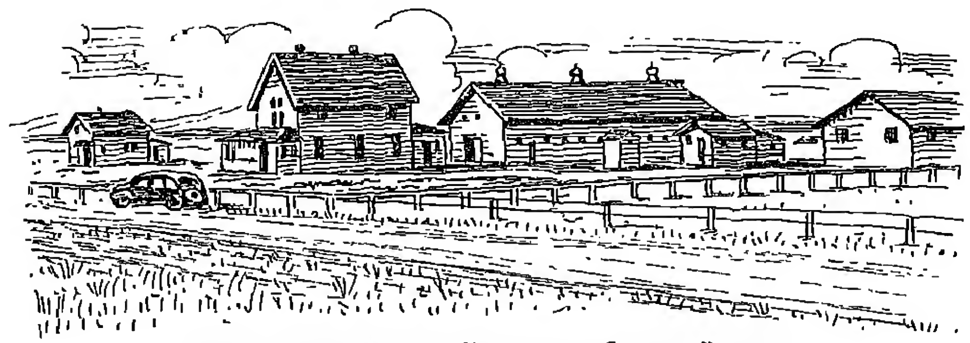


Fig. 59.—A Typical Wheat Farm on the Canadian Prairies.

notice the absence of trees and the flatness of the land.

Lessons on the growing and export of Canadian wheat are clearly of real value. Wheat is an essential food. The wonderful machines used, the long journeys by rail, lake freighters, and ocean steamers, the building of elevators, will all make children realize the cost of wheat. They may think it an easy matter to grow wheat and send it across an ocean that looks so small on map or globe. If Britain were not a rich country, she could buy no wheat. Everyone who wants wheat must work hard to have something to give in exchange, not only for the wheat itself, but the cost of carrying it.

If the story of wheat is not taken in the second year, or if teachers are taking a two-years' course for "What the World Eats," it should be taken in the third or fourth year. In the fourth year it fits in well with the geography of the British Isles.

Older children may like to find on the map, and make notes on, the world's chief wheatlands: Canada, U.S.A., Argentina, Europe, U.S.S.R., South Africa, Northern India, China, Australia.

Oats, Barley, and Rye *(Plate X)*

Oats, barley, and rye need not be treated in such detail as wheat. Children can make a little booklet about each of these grains, telling where it grows and what it is used for. They like especially to find out all the uses of these grains, thus: *oats,* porridge, oat cakes, oatmeal biscuits, food for horses and cattle, etc.; *barley,* flat barley cakes (the barley loaves of Bible days) used in North Africa, Syria, and Eastern countries, brewing of beer and the distilling of whisky, malt used for many malted foods, pearl barley used for soups, etc. The children can find facts for themselves in *What the World Eats* (Evans) and from grocers' shops. It is obvious that lessons on the age-old occupations—planting and harvesting of grains—will enrich the child's vocabulary and are valuable lessons from the point of view of English. Children should be encouraged to make little booklets, illustrated by drawings, telling the story of Planting and Harvesting. Encourage them to make scrap-books containing pictures of machines, etc., used on wheat farms, harvest scenes, etc. Some pages may be kept for an ABC of the wheatfields, and contain such words as—acres (size

of field), bread, binders, cereal, combine, drill, disc, harrows, etc.

Cereals of the Warm Temperate and Tropical Countries—Maize, Millets, Rice, and Wheat (already dealt with).

Children can get some idea as to what *maize* (or *corn* as the Americans call it) is from the picture on Plate X. It is a tall grass that sometimes grows as high as 10 to 12 feet. As the picture shows, it has a much bulkier and heavier ear or head than wheat. An ear or head of maize is called a *cob* and is about $7\frac{1}{2}$ inches long. The children themselves can measure an ear of wheat and compare its length with that of maize. There are hundreds of grains on the cob, which is wrapped in light yellow husks. The cob grows out at a joint about half-way between the top and bottom of the corn stalk. At the top of the stalk is a yellow, red, or green silk-like tassel. Maize needs more heat and more moisture than wheat, but not nearly as much of either as rice. It grows best in warm temperate lands and sub-tropical lands. More than half the world's maize is grown in the north-eastern and central parts of the United States. In South America much maize is grown in Argentina and Brazil.

Maize is chiefly used for fattening cattle and pigs, and feeding fowls. It is used extensively in the United States for this purpose, and Britain and Eire import a great deal for the same purpose. But besides food for animals, maize is an important food for people. In the United States it is eaten as johnny cakes, muffins, cornflakes, mush, canned corn, hominy or porridge, pop-corn. In South Africa maize is the chief food of millions of negroes, who grind it into coarse meal and cook it in pots as "mealies." In Britain it is made into fine white *corn-flour*, which forms the basis of all custard powder and blancmange. It is also used for making ice-cream. Britain gets most of her maize from Argentina. Children will be able to find out in which form maize is sold in their grocer's shop.

In parts of India and China it is also important as food. Only in some places is it used for making flour for bread; for example, in south-eastern Europe. In Spain one often sees maize bread, which is brilliant yellow when cut. The children can find out other places where maize is used in *What the World Eats*.

Millets. There are many different kinds of millets that provide grain food for men and animals in many lands. Millions of people in Northern China, Manchuria, the drier parts of India and Africa, where maize is not cultivated, rely upon millet. There is no need to spend much time over millet, but children are sure to want to know where it is grown and who eats it. Those who are really interested can find out more about millets in *What the World Eats*. Children will be interested to know that the "bird seed" bought for cage birds is a millet imported from Europe, where it is grown. But most millet is used in the land where it is grown, so there is little trade carried on with it. Probably it was grown by the Ancient Egyptians.

Rice. Children are generally interested in the story of rice, and rice makes a good introduction to future lessons on the Monsoon Lands, hot lands where the summers are very wet because in summer wet winds blow regularly. Children are interested to

know that more grain is obtained from a single planted seed of rice than from any other grass. A ricefield grows more food for man than any other field of the same size planted with other grains or vegetable foods. This is a very good thing, because the Monsoon Lands of India, Burma, Indo-China, China, and Japan are very thickly populated and depend upon rice for their "daily bread."

The hand-labour still used in China for cultivating rice should be contrasted with the machinery used for planting and harvesting wheat in Canada. Rice lives for the greater part of its life up to its waist in water. A ricefield in the southern part of China looks like a swamp (Plate XII). Before the seeds are sown, and while the plants are growing, the ground is kept covered with water two inches deep. Even the ploughing is done while the fields are flooded. Some of the water comes from the heavy rain. Some of it is pumped out of canals. Most of the ricefields are near a river or a canal. In the parts of China where rice is grown there are thousands of canals crossing the land in every direction. In some parts men and boys spend many days turning a water-wheel like the one in the picture. The paddles in the trough lift water from the canal and send it into the field.

When the ground is soaked it is ready to plough. Some farmers use machines to plough the land, but some have small wooden ploughs pulled by water buffaloes, as in Plate XII. The seeds are grown first in one corner of the field, a nursery bed. When the little plants are six or seven inches high they are transplanted. Men, women, boys, and girls help to do this. They work all day ankle-deep in mud setting the little plants one by one in long straight rows through the whole field (Plate XII). The men wear bowl-shaped hats made of rice-straw, and the women wrap their heads in blue cotton cloth to keep off the hot sun. Boys and girls help by bringing more bunches of young plants when they are needed. The heavy rains and hot sunshine make the little plants grow very quickly; they often grow as much as six inches in a day. When the rice begins to turn from green to gold the water is drawn off and the crop allowed to ripen dry for the harvest.

Harvesting is also done by hand. The rice is cut with curved knives or sickles, tied in bundles by the reapers and left to dry. The grain is separated from the straw by drawing a handful of the rice plants through a kind of wooden or metal comb fixed in position, or by beating out the grain with sticks or flails as, long ago, wheat was threshed. The children can compare the work of the Chinese in the ricefields with the work of the Egyptians in the wheatfields long ago (see HISTORY, Chart II). It is well to point out to children whenever possible how much of the past there is in the present.

In some of the hot-wet lands rice grows so quickly that three or four crops a year can be harvested. Two crops are common. Most of the rice the people of Britain eat comes from Burma. *Paddy* is rice with the husks still on, or rice in the husk. East of the Suez Canal native rice-growers all know the grain as "paddy."

More Activities for the Children

(1) Children find it interesting to have a geographical museum and begin to collect examples of the different *grasses* used for food. Matchboxes care-

fully labelled may be used for the specimens, and by the side of each box should be a card telling a few interesting facts about the grains. (2) With the help of wrappers and labels, the children make a list of all the cereal foods that are sold, grouping them under the names of the cereals where possible, as —*Oats,* Quaker Oats, Scott's Porage Oats (Scotland); *Wheat,* Shredded Wheat, etc. The children also cut advertisements from newspapers. (3) Interesting booklets or a class book may be made about "Other People's Bread." The children make a list of the different kinds of bread used in different lands and the substitutes for bread. This must be done by degrees, as the children discover new facts, thus:

Wheat. Bread is made from wheat in the British Isles, France, etc.

Oats. Oat cakes in Scotland and Scandinavia.

Rye. Rye bread is called black bread because it is darker in colour than wheat bread. It is eaten in northern Europe—Germany, Poland, and the U.S.S.R. It is heavier than wheat bread, but it forms the staple food of many of the country folk of Europe, who like it better than white bread. Biscuits made of rye flour are becoming popular in Britain because they are nourishing without being fattening.

Barley. Flat barley cakes eaten in North Africa, Syria (children add the names of more places if they can find them).

Maize. Yellow bread, south and south-eastern Europe, Spain, Mexico.

Farina or flour of the *manioc root* (this also gives us our tapioca). This root is known as *cassava* in the West Indies, south-east Asia, and in tropical West Africa.

The *bread-fruit tree.* In the South Seas many Islanders eat the fruit of the bread-fruit tree.

Chestnut flour. In many parts of Italy peasants make bread and cakes of chestnut flour as well as from maize or wheat.

Buckwheat flour; buckwheat is not a cereal. It is a low herb which grows very quickly on poor soils. The fruit has a dark-brown tough rind enclosing the kernel. It is three-sided in form with sharp angles, hence its name *buck,* meaning *beech.* It is used for cakes in the United States and in Northern Europe; in Holland it is made into crumpets. It is also used in the Himalayas.

What people eat no bread? This question interests children.

Vegetables

These are best taken in connection with local geography and the geography of the British Isles, and above all in connection with nature study. See suggestion for the work of the fourth year in Volume IV, Nature Study. However, children will probably want a talk about vegetables if their syllabus is "What the World Eats," and *children should always know the syllabus they have to cover.* It is well, too, for children to take the same topic from different points of view.

Children are very keen on learning that different vegetables are different parts of plants. Some vegetables are (1) the *fruits* of plants, tomato, cucumbers, etc.; (2) the *leaves,* cabbage, parsley, etc.; (3) the *seeds,* peas, beans; (4) the *stems* and *leafstalks,* celery is a leaf-stalk, each with its leaves on the end, asparagus is the stem of a plant; (5) *the roots,* carrots, parsnips; (6) *tubers*

or swollen underground stems, potatoes; (7) *bulbs*, onions.

Children enjoy seeing how many names of vegetables they can collect under the above headings. They will learn much of interest about the potato from the point of view of geography in *What the World Eats* (Evans).

Food from the Sea

This is an interesting and important topic. It can be dealt with in the third year or in connection with the British Isles in the fourth year.

The most important fishing-grounds in the world are in the North Temperate Zone, because there are certain places here where fish gather together in great numbers to feed or lay their eggs. The chief food sought by the fish consists of minute floating animals and plants called "plankton." Plankton is the "pasture" of the sea, and is often thickest in the cold currents from the North Polar Sea, as, for example, the Labrador current which flows to the Grand Bank of Newfoundland. This current is often so thick with plankton that it is greenish in colour. Millions of fish are attracted to it. Not only do fish go there to feed on plankton, but other fish follow them to feed on them!

One of the largest fishing-grounds in the world is the *shallows* or *banks* of north-eastern North America, especially the world-famous Grand Bank of Newfoundland. Explain to the children that "banks" are where the sea is much shallower than the ocean deeps. Many kinds of fish are caught on the Grand Bank—cod, haddock, mackerel, herring, etc., but especially *cod*. Fishermen from many parts of the world come here, as well as from the countries near the banks, Labrador, Canada, and the United States. In the history lessons, the children will learn how John Cabot discovered the island of Newfoundland, which lies off the east coast of Canada, in 1497. Ever since then fishermen from Europe have been crossing the Atlantic to catch codfish in the waters near Newfoundland and the shores of North America. The children will guess why the name Cape Cod was given long ago to one of the capes of North America between New York and Boston.

Another important fishing-bank is the shallows and banks of north-western Europe, including the famous Dogger Bank.

The children make contributions to the lessons by telling about the fish seen in their fish shops. They find out where it comes from, the nearest fishing ports to their town, how the fish comes to their town by train or lorry, and so on. It is important for them to know the port or market from which they get their fish. Just what local geography is taken depends on the situation of the school, but local geography must continue with world geography.

The Work of the Fishermen

Children should know something about the work of the fishermen (here a talk over the radio by a fisherman might be of value, see Chapter I). It adds to their experiences and vocabulary. There are "long-shore" fishermen and deep-sea fishermen. Fish that haunt the shores, like sprats, are caught by "long-shore" men. "Long-shore" is for "along shore," men who fish "along the shore" in small boats are called "long-shore men."

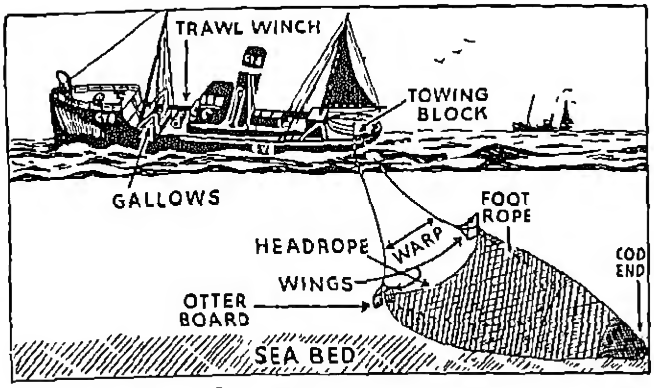


Fig. 60.—Trawlers Otter Boards keep the Wide Mouth of the Trawl open. The Foot Rope with Large Bobbins drags on the Sea Floor

Fish that live far away from the coast are caught by " deep-sea " fishermen.

(1) The *steam trawlers* catch fish living on or near the bottom of the sea; the valuable flat fish—plaice, soles, turbot, halibut—that live in the mud at the bottom of the sea, as well as cod, hake, haddock, and other fish that swim near the bottom. They are caught by a large bag-net, called a trawl (Fig. 60) because it trawls or drags along the bottom of the sea. The ports from which these trawlers chiefly set out are Hull and Grimsby, Aberdeen and Fleetwood. Trawlers are often at sea for weeks, for some go great distances in search of good fish — to Iceland, the White Sea, the Faroe Islands, south and west of Ireland, and even the coast of Morocco. They carry ice on board, and the fish are packed in it during transport to land

(2) *Steam drifters* (Fig. 61). Herrings, mackerel, and sprats, or fish that swim near the surface of the sea, are caught in drift-nets. A drift-net may be two miles long. It is kept floating upright because it has cork floats along the top edge, and weights along the bottom edge. The ships using the drift-nets are called drifters because they are allowed to drift with the tide when once the net is let down. When the drifter meets a shoal of herrings thousands of the fish swim into the long wall of net and are caught in the meshes. Lowestoft and Yarmouth are two important ports for the herring industry, Britain's most important fishing business.

(3) *Lines with hooks and baits.* Fishermen on the Grand Banks of Newfoundland use a long line, perhaps three miles long, that they call a trawl. It has about 3,000 little lines tied to it, each with a hook and bait. The trawls are kept stretched at the bottom of the sea by anchors, and a buoy marks one end of each. Many cod are caught in this way, most of them being salted,

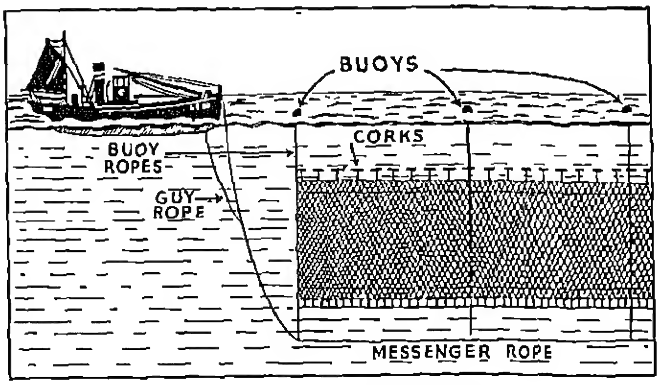


Fig. 61.—Drifter and Drift-net.

dried, and sent to South America, the United States or Southern Europe. Kipling's *Captains Courageous* gives a good account of the dangers of cod-fishing on the Grand Bank of Newfoundland. Then stories can be told about (1) the *pilchard* fishers of Cornwall; (2) the *oyster* men of the muddy creeks and estuaries, especially those of south-east England, Whitstable, Colchester, etc.; (3) where shellfish are found and how they are caught, crabs, lobsters, cockles, and shrimps; (4) salmon, etc.

The A children can read for themselves more about fishing in *What the World Eats* (Evans).

Oils and Fats from Plants or Vegetable Oils

These are so important today and the plants themselves so interesting to children that they are well worth taking in the Primary School.

(1) *Olives* especially interest children because of their lessons on Ancient Greece (see Volume II). They know how useful the olives were to the Greeks of long ago. Today they are still a most valuable food for the people of the Mediterranean because they have so little butter or meat. The children can read about the olive in *What the World Eats* (Evans). They may have eaten or seen tins of sardines preserved in olive oil.

(2) The *oil-palm* (Plate XIV) grows in the hot-wet forests of Africa, especially in the countries fringing the Gulf of Guinea in West Africa. It is from the oil of the oil-palm that a good deal of margarine is made. Plate XIV shows the palm-tree and a *head of fruits*. The fruits, as can be seen, grow in great clusters; they are like very small plums and dark red or orange in colour. The natives crush the fruits and use the oil that runs out as food. They do not use the stones or kernels, although they contain oil. These are exported; the countries that buy them crush them to obtain the oil, which is excellent for making *margarine, fat, candles*, and *soap*.

The children can learn a great deal by studying Plate XIV. They see how big a *head of fruits* is compared with a man, how the natives crush the fruits to get oil from them. The kernels are set aside to dry for export. The kernels that are exported generally come from oil-palms near the sea. Why?

(3) *The Coconut-palm* (Plate XIV). These palms also supply oil for *margarine*, etc. They like hot sunshine, heavy rain, *and sea-air*, so they are a common sight along tropical shores. Millions of them are cultivated in plantations, especially in Ceylon and Malaya. They also grow in Southern India, in the East Indies, the West Indies, the islands of the South Seas, and other tropical shores and islands.

Children, in connection with their nature study, are always interested to learn how the wild coconut trees scatter their seeds. The seed is well provided with food and protected by a hard shell which has a soft spot in its upper end for the seedling to grow out of. The nut is also protected by a thick husk or coir (Plate XIV) of a fibrous structure, so that the coconut can float in water for a long time without being hurt. As the wild palms grow close to the sea and often overhang it, the ripe nuts drop into it. They float on the water until they are washed ashore somewhere by the tide. Then they take root and grow.

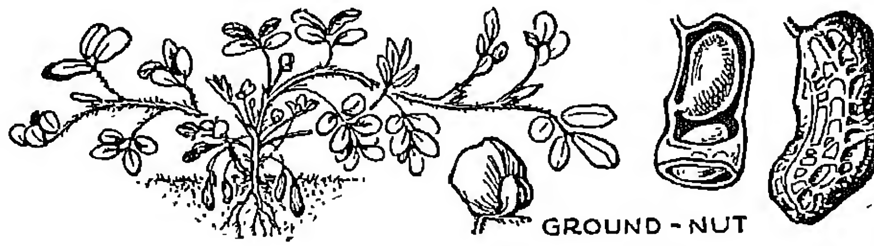


Fig 62.—Ground-nut Plant, Flower, and Nut.

The coconut is the most wonderful nut in the world, for it gives to the natives of the tropics almost everything they want. If anyone is hungry, he can break open a coconut and eat the white kernel, the "meat" as it is called, because it really makes a good meal. If he is thirsty, he can drink the juice or "milk." Coconut "meat" is also full of oil that the natives press out and use for cooking and for butter; the dry meat that is left is used for fodder for animals.

From the hard shells of coconuts the natives make cups, bowls, dishes, spoons, buttons, and ornaments. The husk or coir gives coarse fibres for brushes, brooms, and long fibres that can be spun into yarn for ship's ropes and cord, or woven into floor-matting and door-mats. The leaves are used for thatching, the split leaflets are used by the natives for weaving mats and baskets, their strong mid-ribs are used for garden brooms.

But the planters who grow these palms do it for the sake of the kernel or "white meat." This is dried as copra. The copra is sent to local mills or mills overseas, where the oil is crushed out of it and made into *margarine*, or *soap*, etc. The best kernels are sometimes shredded and sold for cake-making, coconut icing, sweets, macaroons, etc.

(3) *Ground-nuts* (Fig. 62). Children will like to learn something about these so-called "nuts," because they may know them as peanuts or "monkey nuts." They are not really nuts at all, but the fruit of a small creeping plant that grows best in hot lands, such as West and East Africa, India, Brazil, Egypt, etc. West Africa produces most, especially Nigeria. The plant forms its fruit in green pods close to the ground; but the fruit gradually bends earthwards until it is buried beneath two or three inches of soil, where it ripens. When ripe the "nut" has a thin yellow shell containing two or three brown-skinned kernels Ground-nuts are eaten plain or roasted, but most of them are grown in order to produce oil. This oil can be used for all the purposes that olive oil is used.

Activities on the Part of the Children

(1) Collecting pictures and specimens if possible of every kind of nut—including two nuts that are not really nuts—the ground-nut and almond. There are chapters in *What the World Eats* to help them, and they can find all the nuts that grow in Britain—acorns, horse-chestnuts, etc.

(2) Let the children measure out on the playground a length of twenty feet so that they can get some idea of the length of the coconut-palm leaf. There may be some tall building near the

school that will give them some idea of how tall a palm sixty feet high is.

(3) A problem. An Indian legend tells how a certain king built, fitted, loaded, and provisioned a ship entirely from coconut-palm products. The children work out how this could be done. They will be able to find another food from the coconut-palm in *What the World Eats.* They may also get ideas from encyclopædias, etc.

(4) The children find on the flat map of the world or a globe all the *tropical* shores or islands where the coconut-palm might grow.

(5) For a class project the children make a book about Useful Palm-trees—this, of course, will include the date-palm. Many children will want to make booklets about the Coconut-palm.

(6) *Reading*—Parts of *What the World Eats,* and the story of the origin of the coconut-palm in *Round the World in Stories* (Univ. London Press). This is a tale of the East Indies. Interesting stories about food—the lobster, the story of rice, the corn family, etc., will be found in *A Tale in Everything* (Univ. London Press).

Dairy Produce, Beef, and Mutton

Dairy Produce: this can be dealt with in the fourth year in connection with the British Isles (or whatever the home country is). Milk is dealt with in the fourth year in the nature study and simple science lessons (see Volume IV).

Beef: the grasslands of South America.

Mutton: see third year's work.

Some Pleasant Drinks

Water, cocoa, coffee, tea. Point out to children the value of water. It is necessary to life, and is contained in almost every food we eat. It is in the juice of fruit, in milk, in vegetables, and in bread and meat, etc. We cannot enjoy a drink without water—tea, coffee, cocoa, lemonade, etc., all need water. Water can be left until the fourth year and taken in connection with the reservoirs of the British Isles. But the children will enjoy a talk about water in connection with food. Material for a talk will be found in *What the World Eats* (Evans), and an interesting project in *Projects for the Junior School,* Book IV (Harrap).

Cocoa and chocolate are foods as well as drinks. Both come from the powder prepared from the seeds of the *cacao* tree (as the word *cacao* is difficult to pronounce, it is generally called the *cocoa* tree). Cocoa trees grow best in the equatorial lands where there is very little wind (which is harmful because it blows off the pods), and where there are no seasons, but plenty of hot sunshine and rain. In the first year the children have learnt about the homes of the negroes in Equatorial Africa. Again emphasize the rain and sunshine. There are no seasons, only the time of the Big Rains and the time of the Little Rains. In the time of the Big Rains there is still plenty of sunshine. The forest areas of Africa are very useful to the negro cocoa-growers, who cut away the undergrowth but leave the taller trees standing to shade and protect the young cocoa trees.

More than half the world's supply of cocoa comes from the Gold Coast and Nigeria. Pictures and descriptions of the cocoa pods and tree (which is about the size of an apple tree) will be found in *What the World Eats* (Evans). Interesting pictures and booklets about

the growing and harvesting of cocoa pods can be obtained from Cadbury Brothers, Ltd., Bournville Works, Birmingham.

Tea and Coffee. Material for lessons will be found in *What the World Eats* (Evans).

Packets of six photographic cards with descriptive leaflet and map, price 1*s.*, may be obtained from the Imperial Institute, South Kensington, S.W.7, illustrating the following topics: (1) The Cultivation of Tea in India, (2) The Manufacture of Tea in India, (3) The Ceylon Tea Industry, (4) The Production of Coffee in Kenya, (5) The Cocoa Industry in British West Africa.

Suggestions for a Lesson on Coffee *(Plate XV)*

It is often wise to begin the story of a product "at home"; then take the children an imaginary journey to a coffee plantation. This helps to keep regional geography in touch with world geography. The children have probably seen coffee beans or berries, and watched the grocer grinding them in the shop. Tell them they are going a journey to see where it grows. Coffee needs heat and a rich *well-drained* soil. Where will they look for it? It is often grown on the highlands facing the tropical sea and in the sub-tropics. Most of the coffee used in the world comes from the highlands of Brazil in South America. The children use the globe and a flat map of the world to see where South America and Brazil are in relation to Britain and the port of Southampton from which they are to sail. They also look for the Equator. South America and Brazil, they see, lie far south of Britain; to be exact, south-west. Brazil is easy to find, for it is the largest country in South America; they soon find the Amazon with the Equator running across its mouth. The children see in which direction they must travel across the Atlantic Ocean.

The liner from Southampton passes the Bay of Biscay, calls at places in Spain and Portugal, gives the passengers a peep at Madeira, and passes the Canary Islands and Cape Verde Islands. Then come miles and miles of ocean with no sight of land; the Equator is crossed, and just over a fortnight after leaving Britain the high coast of Brazil is seen, and the ship steams into one of the most beautiful harbours in the world—Rio de Janeiro, called Rio for short. After landing passengers and goods, the ship goes farther south for about 200 miles to Santos, the chief coffee port of Brazil. Here signs of coffee can be seen, for there are heaps of big bags of coffee "berries," or "beans," ready to be taken on board the next steamer to England.

A train goes from Santos up into the hills and into the very heart of the coffee country, the great coffee plantations on top of the plateau behind the town of Sao Paulo, the coffee capital. Here are young bushes and old bushes all carefully set in rows in the rich red earth. Between the rows of the young coffee trees the planter has tall bananas growing. The big leaves of the banana shade the young trees from the hot sun of noontide. When they are full-grown trees they need no shade.

Each coffee bush is shaped something like a small haystack, with a round top (Plate XV). The little blossoms are star-shaped and grow in clusters. They change to bright-red berries about the size of a small cherry. When the

pickers gather the coffee, they run their hands along the whole length of a branch. This strips off the berries. Sometimes the pickers put the berries into baskets or bags and sometimes they let them fall into a sheet laid on the ground. The pickers are Brazilians. They speak Portuguese, for the Portuguese people came to Brazil more than four hundred years ago and made their home there. Although the coffee berries look tempting to eat, they do not taste like cherries, and no one cares to eat them. Inside are two hard little bluish seeds (often wrongly called "beans") with their flat sides touching each other and their rounded sides outermost. The pickers put their filled baskets on one of the little cars that run on lines laid through the plantation. They are taken to long, low, wide-roofed buildings where the berries have their seeds removed. The seeds or beans are washed clean and spread out on great open floors of cement to dry in the hot sunshine. All the time dark-skinned men in cotton garments rake them and turn them over so that every seed or "bean" is dried thoroughly. When the "beans" are dry they have their paper-like skins taken off by hulling, and are then sorted according to size, packed in bags, and sent by rail down to the seaport of Santos. Children, with the help of Plate XV, will be able to tell the story of coffee.

Sugar, Salt, Spices, etc.

Remind the children that the first "sugar" used in Britain was honey, and from the days of the cave-men onwards for hundreds of years honey was the only means of sweetening food. The children will enjoy hunting through their History Charts I–XIV to find out when sugar was first used in Britain.

Sugar comes from (1) the sugar-cane which grows in the hot-wet lands, the tropics, and (2) from the sugar-beet that grows in temperate lands, northern Europe (Germany, Poland, and Russia) and Britain. In Britain sugar-beet grows in East Anglia, where there is enough sunshine to help the beet to make sugar and enough rain to swell the root. The sugar-beet will be dealt with again in the fourth year, when the British Isles are taken in more detail. Children can read for themselves about sugar-beet in *What the World Eats* (Evans). But most of the world's sugar comes from the sugar-cane. Sugar-cane is really one of the grasses. The children will remember another important food that comes from the grass family—cereals. But sugar-cane is a giant grass. In some lands it grows to a height of 20 feet. The children can compare the height of the sugar-cane with the height of someone, say their father, who is six feet tall.

Men who grow sugar-cane for the sugar do not allow it to grow too tall, generally not higher than 12 feet. The pith of the stalk contains the sugar. Plate XIII will help children to understand this description of a sugar-cane plantation in Cuba. On all sides we see stretches of tall, waving canes, their long, pointed, dark-green leaves rustling softly and pleasantly in the breeze. The sugar-canes grow close together in long, straight rows with wide paths between the rows. In the tropics the canes grow all the year round, so that some fields are filled with the paler green of young canes and some are thick with the dark-green leaves of canes rapidly ripening. Here and there in the plantation the

white house of an overseer can be seen, or little blocks of houses where the negro workers live. In some fields it may be harvest-time. The men cut through the thick stalks close to the ground, because the lower part has most juice. It is from this juice that sugar is made. The cutters use heavy knives with a sharp edge on one side and a hook at the end for pulling off the leaves. While some reap the canes with rhythmic blows, and cut off the tops and leaves, others "head" them away to bullock-carts or a light railway for transport to the sugar-mills. In the mills are gigantic steel mangles driven by powerful steam-engines that crush the juice out of the canes. The rich juice goes to another part of the factory where the sugar is extracted. There is no need to trouble the children with all the many processes necessary before "raw sugar" is obtained. The refining of "raw sugar" is the work of all big sugar-consuming countries. There are important sugar refineries in London, Liverpool, and Greenwich. *Refined sugar* is sold in the familiar forms of granulated sugar, loaf sugar, castor sugar, icing sugar. Sugar refineries all make golden syrup.

Most of the world's sugar is grown in (1) *India,* where the people use it for themselves and export none, (2) *the West Indies,* Cuba and Jamaica, which export a great deal; (3) *the East Indies,* especially Java, which also exports a great deal. Other places where the sugar-cane grows are: (1) tropical islands like Trinidad, Hawaii, Mauritius, Formosa, Philippines; (2) Australia, the tropical coastlands of Queensland. Australia grows enough sugar for herself and for export, chiefly to Great Britain; (3) the coastlands of Natal, which produce enough sugar for South Africa; (4) Peru, Brazil, and Guiana in South America (brown sugar called Demerara after Demerara in Guiana is cane sugar which is not completely purified); (5) the United States (southern States, as Louisiana); (6) China. Children are interested to know that the first home of the sugar-cane was China. A great deal is still grown in Southern China, though how much we do not know. From Asia the sugar-cane spread to Africa and the New World. Children will enjoy reading about the origin of the sugar-cane in China in *Round the World in Stories* (Univ. London Press).

It is most important when giving lessons on the sugar-cane to point out that cane sugar is a finished food product laboriously built up with the aid of sunlight *by the leaves of the plant for its own use* from such very simple materials as carbon dioxide and water; a feat which has not yet been accomplished by man. In the nature study lessons the children will learn about carbon dioxide and plants. This association between nature study and geography is most valuable and makes children think. They must be alert to use the information gained in one subject in another. Impress upon the children that neither the sugar-mills that supply raw sugar, nor the refineries, *make* sugar; they merely extract and refine sugar which the plant has already made.

Children by now may have noticed how many pleasant foods we get from the tropics. Remind them that whenever they sit down to a meal they touch the tropics. Ask them if this is true—"There is no meal served in Britain in which sugar does not play a part either in the cooking or the serving."

Maple Sugar may be discussed with the children in connection with the temperate forests of North America. The sugar-maple trees grow chiefly in eastern Canada and the north-east of the United States. In the spring of the year the sap begins to run up through the trunks of the trees. At the right time a small round hole is bored in the trunk of each tree, a little way above the ground. A spout is driven into the hole and a bucket hung under it to catch the clear white sap that drips slowly out. Every day buckets of sap are taken to a building known as the sugar-house, where it is boiled until it becomes thick and turns into the gold-coloured maple syrup that tastes so good on waffles, pancakes, rice, etc., or with buckwheat cakes—a great American favourite. If the sap is boiled longer, it turns to sugar.

The Pilgrim Fathers learnt how to make syrup from the Red Indians, who cut holes in the trees with their tomahawks and drove in spouts made of curved pieces of bark. This will remind the children of their first year's work about the homes of the Red Indians. Children of both the first and second year will enjoy the Red Indian play called "The Moon of Sugar" in *Eight Easy Plays* (Univ. London Press). The month of March was called by the Indians the Sugar Month. In that month they used to pitch their wigwams in or near forests where there were many sugar-maple trees. Children like to compare the legend of the sugar-cane (see *A Tale in Everything*, Univ. London Press) with the Indian legend of the maple. Let them think which legend contains the more truth.

Honey, the "sugar" made by bees, the children will learn about in the nature-study lessons. Many children will be interested in "bee farmers," and enjoy finding information about them, and the plants that bees like, in *What the World Eats* (Evans).

Salt and *mustard* may be dealt with when the children are studying the British Isles. Salt interests children greatly, because it is a *mineral* food. In the nature-study lessons (Chapter IV, Volume IV) they will learn how in hot countries salt is obtained by evaporating sea-water. This is one of the oldest ways of obtaining salt. Most of the salt we buy is dug out of mines or pumped out of wells deep under the ground. It comes from the layers of salt, like rocks, which have formed underground. Long ago salt lakes covered the land. Finally the water dried up and just the salt was left. Then these layers of salt were covered in time with layers of soil and pressed into salt rocks. In the salt-mines, machinery digs the salt from below the surface of the earth, just as if it were coal. Children who are interested in salt and mustard can read more about them in *What the World Eats* (Evans).

If time permits, something might be said about spices. Spices were once a necessity, now they are a luxury—the children will be familiar with them because of their history lessons. Spices are another product of the hot-wet lands. When one touches pepper one is touching the tropics.

More Projects and Activities

(1) Children enjoy making booklets about "Meal-times across the World" or "Dinner-time Round the World," and planning suitable dinners for Eskimos in the Cold Lands, Negroes

in the Hot Lands, etc. See *Projects for the Junior School*, Book I, Chapter VI (Harrap).

(2) Children find it interesting to collect the names of all the trees, bushes, plants, grasses, etc., that give the world food. This is a class project and works in well with nature study, as the trees, etc., can be arranged under headings: (*a*) palms; (*b*) evergreen trees, the olive; (*c*) deciduous trees, the chestnut. Interesting friezes and brown-paper booklets can be made, and the children will be able to make many suggestions; for example, a booklet about "Food Trees of the Temperate Lands" or "Food Trees of Britain," and so on.

(3) Booklets about sugar—beginning at home with all the kinds of sugar sold in the grocer's shop.

(4) A Farm Project is especially suitable for rural schools. One particular farm can be chosen—a dairy farm or mixed farm. Groups of children can be made responsible for each kind of work on the farm and bring to school notes and information about it; for example: (*a*) The care of pigs. (*b*) The work of shepherds. (*c*) Ploughmen—who must know something about the soil. (*d*) The cowman, who must know what food to give the cows, how much to buy, how much milk is sent away, etc. (*e*) Tractors on a farm. (*f*) Poultry—and so on. Much arithmetic is involved—the size of the arable fields, the grass-lands, etc., in acres. How the milk is sold. How many eggs are sold a week. Prices of things sold and bought. Children enjoy making booklets about the tools used on a farm. They should be able to visit farms or to write to farms to get facts and impressions. There are endless possibilities in a farm project. See also Chapter X.

CHAPTER NINE

REGIONAL AND WORLD GEOGRAPHY FOR THE THIRD YEAR

MANY teachers may want to take part of this year for finishing "What the World Eats." "What the World Wears," however, gives the children a new outlook, and introduces them to the great industrial towns of the world. It also prepares the way (as do all the syllabuses) for the fourth year's work—a more detailed study of the home country, Great Britain, or whatever the home country may be.

Furs (*Plate XVII*)

The story of furs makes a good beginning. It reminds the children of their first year's work in history. As far back in time as we can go, men wore furs. At first they were used only for their warmth, as they still are today by many people in the Far North—the Alaskans, Indians, and Eskimos of North America, the Laplanders and other tribes of Northern Europe and Asia. But as time went on they were soon used in many parts of the world not only for their *warmth* but for their *beauty*. In olden days to wear some furs was a sign of high birth or royalty; for example, the *ermine* cloaks of kings.

The greatest number of fur-bearing animals and the most valuable live in the cool pine forests of the temperate lands of the Northern Hemisphere where the winters are long and cold. The children find the cool forests on their atlas map of the world (Johnston's School Atlas). Farther north of the pine forests is the cold belt where trees cannot grow. Here in this frozen desert or tundra, where only moss and low plants grow in the short summer, are more fur-bearing creatures: the Arctic fox, the caribou, the seal, etc. All this is good revision of regional and world geography. The children may see for themselves that the position of Canada and Siberia makes them the chief fur-producers of the world. The children will enjoy hearing or reading about the fur-trappers (white, Indian, or Eskimo) of Canada and Siberia in *What the World Wears* (Harrap), also in R. M. Ballantyne's *The Young Fur-Traders* (P. R. Gawthorn).

It is difficult to give the children in words an idea of the vastness of the Canadian North-West, where the best furs are found. In the Far North, which extends up to and beyond the Arctic Circle, the fur trade depends to a large extent on the Eskimos. They obtain many of their furs from the creatures of the sea—the seal, the hair seal, and seal otter.

The children may like to compare the fur-trappers of Canada with those of Siberia (the U.S.S.R.). It is not so easy to get accurate information about

the fur trade of Siberia as it is about Canada. We know the northern regions of the Soviet Union are rich in furs, squirrel, fox, ermine, bear, and one of the most valuable fur-bearing animals, the grey squirrel. (See Plate XVII and also Plate XIX, NATURE STUDY.)

The children compare the wooden houses of the hunters in Canada with those in Siberia (see *Other People's Houses*, Harrap). The Siberian hunters ride to the edge of the forest where they are going to hunt in sledges drawn by reindeer, but the Canadian hunters use sledges drawn by a team of dogs called *huskies*. These strong, fierce dogs are almost like wolves. The Siberian hunter shoots the squirrels and has a well-trained dog who finds and brings the quarry to his master. The Canadian trapper often thinks he is lucky if he gets a few marten, a silver-black fox (a great prize), or even a wolf (see *What the World Wears*). The children may, if time permits, like to hear about fur farming.

To encourage children to read for themselves, they can be given a list of important fur-bearing animals and told to find out more about them by looking at natural-history books, zoo books, etc. Here is a list (see Plate XVII): *beaver*, *ermine* (the most valuable fur in the world; ermine is really the winter dress of the stoat, a kind of weasel which is brown in summer but pure white in winter except for the tip of its tail, which is black; it inhabits Europe, Siberia, China, and Canada), *marten* (the fur resembles sable), *mink* (one of the chief fur-bearing animals; its home is in marshy regions), *mole*, *musk rat* or *musquash* (North America, a very important fur-bearing animal), *raccoon* (the word *coon*, often found in negro songs and folk-tales, is a short form of raccoon. The raccoon, although small, belongs to the bear family; it is found almost everywhere in the United States), *rabbits* (Australia, New Zealand, and almost everywhere). Rabbit fur is never sold under its name "rabbit," but under the old name once used for rabbits—*cony*. Rabbit fur can be made to imitate almost every fur. *Lynx* (see Plate I, NATURE STUDY).

Wool *(Plate XVI)*

Lessons on wool will include hair-bearing animals such as goats, yaks, camels, alpaca, llamas, etc., especially Angora and Cashmere goats. Pictures of these interesting animals will be found in *What the World Wears* (Harrap), as well as on Plate XVI.

Not too much time need be spent over the processes of preparing woollen yarn and cloth. In their craft lessons (Volume IV), the children will get a good understanding of spinning and weaving by hand. This is necessary if children are to appreciate the work done by the wonderful machines in woollen and cotton factories or mills. It might be explained to the children that wool is easy to spin because each fibre is not perfectly smooth but covered with tiny scales. These help the fibres to hold together when they are spun. It is because of these scales that wool mats easily to form felt (cf. felt tents of the Kirghiz). These little scales can be seen under a microscope (Fig. 63).

Most attention must be given to world geography. The story of wool takes children to grasslands all over the world, for sheep are perhaps the most numerous of all domestic animals. They are reared not only for wool, but

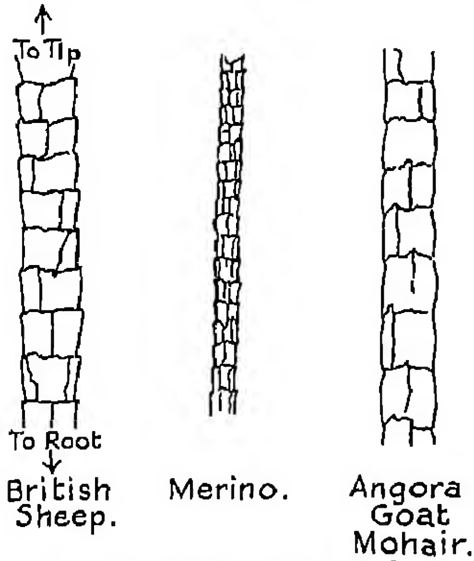


Fig. 63.—Wool Fibres seen under a Microscope.

for mutton. It is in the drier, sunnier grasslands that they are reared for wool, and in the better grasslands where pasture is richer that we find mutton sheep. In Canada and the United States, for example, sheep are reared in the drier West for their wool, and in the wetter East for mutton.

Most of the countries north of the Equator keep the products of their sheep mainly for their own use. It is the countries south of the Equator that have the enormous sheep-farms from which wool and mutton are sent in great quantities to other lands—Australia, New Zealand, the Argentine, and South Africa. Let the children find first on the map the sheep lands of the Southern Hemisphere. Australia has the most sheep in the world, and she rears most of them for their wool. Plate XVI shows a fine merino sheep. These are sheep which are kept entirely for their wool, for the meat they give is not very good. Their wool is excellent, one of the best wools for clothing. These sheep were famous in Spain long ago, and the word *merino* is a Spanish word meaning "of a larger kind." The children can see from Plate XVI what a large coat of wool the merino sheep has. As these sheep are natives of North Africa, which is warm and dry, they flourish in those parts of the world that are too hot and dry for other sheep. The climate and pastures of South Africa and Australia are exactly right for merino sheep, which like bright, dry weather and not much rain.

Remind the children that wool was once the source of England's wealth and her chief *export* (see Volume II, History); the wool from her sheep today is still the finest in the world, and her sheep have been introduced into other countries; for example, New Zealand and Argentina. As well as good wool, these sheep produce good mutton. As the climate of New Zealand is more like that of Great Britain than Australia, mutton sheep flourish in New Zealand. Although New Zealand has fewer sheep than Australia, she leads the way in the export of mutton. "Canterbury lamb" from the Canterbury Plain on South Island is famous. The children can find this plain on a map of New Zealand.

In Argentina the most popular sheep are those that produce good wool and good mutton. The southern part of Argentina, called Patagonia, is especially famous for its sheep-farms. On the Falkland Islands, not very far from the coast of Patagonia, the chief occupation of the people is the keeping of sheep. Brazil and Peru have a number of merino sheep.

In the fourth year, when children are learning about the woollen towns of

Yorkshire, they will understand why Yorkshire gets most of her wool from Australia, New Zealand, South Africa, and the Argentine.

Now let the children find places in the Northern Hemisphere where sheep are reared. They look at a relief map of North America and notice the mountains in the west, the Rocky Mountains and the uplands and plains, especially the plains to the east. There are many sheep-ranches here. The sheep are taken in large flocks to special places called ranges, along the slopes of the hills and on the sides of the mountains. The sheep stay on the ranges about nine months every year. The man who takes care of the sheep on the ranges is the herder or shepherd. He has dogs to help him, and the man and the dogs stay with the sheep night and day, all through the grazing season. They move from one part of the range to another after the sheep have eaten all the grass in one place. Usually the herder lives in a wagon which he drives along with the sheep whenever he moves them to a new part of the range. A man called a camp tender brings food to the shepherd whenever he needs a fresh supply. In the summer, the herder takes his sheep to grazing lands among the mountains. Then he lives in a tent, because he cannot drive his wagon up and down the steep slopes.

The shepherd keeps his sheep on the ranges as far into the winter as he can. Sheep need not go into barns in the cold weather because their thick wool coats keep them warm. When the ground is covered with snow and the sheep cannot get at the grass, the shepherd gives them a special food made from grain. During January and February in the Northern States of America and in Canada the shepherd must move his sheep back to the farms for winter feeding. Another reason for going home is that the little lambs are born in the spring and must be cared for in barns. The children will see that many more sheep are reared in the United States than in Canada because Canada is farther north and the winters much more severe. The sheep have therefore to be kept in barns longer and fed on food specially grown for them on the farm, or bought. This makes the rearing of sheep expensive. In the United States the sheep are kept out on the range for at least nine months, and in the south practically all the year, so their food costs very little.

The children have now two pictures of North America, the prairies or wheatlands of Canada and the sheep ranges of the United States. Remind the children that there are also great wheatlands in the plains of the United States.

The sheep of North Africa have already been mentioned. In North Africa the Barbary sheep, the rams with long flowing beards or mane and large horns, make a very fine appearance (Plate XVI). They seem able to live on ground where there is little or no water, grass, or vegetation. The children may remember the goats of Nigeria (see Plate VII). The dividing-line between sheep and goats, like that between wool and hair, is indistinct.

Sheep are reared in most countries in Europe, but most of the wool is used in the country where it is produced. There are no great sheep-farms.

In the fourth year the children will learn about sheep in the British Isles. Spain, the native home of the merino, is no longer famous for her fine wool as

in the past. Children will like to hear something about the shepherds of Greece because of their history lessons. There are shepherds in the Balkan peninsula as there were long ago in the days of the Trojan War or the days of Alexander. The children will be studying Europe in detail in the Secondary School.

The wools of the U.S.S.R. are varied because of its vast size. The children have already learnt in the first year about the wandering shepherds of the steppes and their felt tents. Here is an opportunity for revision. They will like the picture of the Kirghiz shepherd and his lamb (Plate XVI). It is from very curly-haired black lambs that astrakhan is made—this popular fur is also known as Persian lambskin. Sheep in Asia are numerous but not important. There are all colours of sheep and goats from white to grey, brown, and black; this makes their wool of less value. Some Asiatic sheep differ in appearance from English sheep, they are semi-wild, and have fat tails and long ears (see Plate XVI). The children will remember the Persian shepherds and Cyprus the Shepherd (Volume II, HISTORY). In India there are few sheep but many goats. Most of the wool from Iran, India, China, Mongolia, etc., is coarse wool mixed with hair and used for carpets.

By exploring maps to find lands where there are sheep, the children will realize how few countries there are where wool is not grown, and that sheep live under the best conditions and produce the most wool in the temperate zones. There are sheep as far north as Iceland, and as far south as New Zealand and the Falkland Islands. By finding the homes not only of sheep but of the alpaca, llama, Angora goat, Cashmere goat and other wool- and hair-bearing animals, the children learn to find their way about the world. They are also interested in these animals (Plate XVI) and want to find out more about them.

Some children may now want to know the difference between *wool* and *hair*. Wool is *curly*, crimpy, and flexible; hair is stiff and straight (cf. dog's hair, horse-hair). But hair of the camel class is fairly soft and "woolly." *Mohair* is the hair of the Angora goat, a native of Asia Minor named after the Angora district. This is the most important of commercial hairs. Apart from silk, it is the most lustrous of animal fibres, and before *rayon* or artificial silk was invented it was very popular for dresses. It is still used for plushes, velvets, imitation furs, astrakhans, and especially for linings. Alpaca is made from the soft "woolly" hair of the alpaca and the llama (Plate XVI). Alpaca is as smooth as mohair and soft as wool. Cashmere is the most beautiful of the rarer wools. The Cashmere goat does not live in Kashmir but chiefly in the central highlands of Asia from China to Bokhara.

Thoughtful children, hearing about the wool of sheep and the hair of the Angora goat, may begin to wonder what *fur* is. As far as possible the questions asked by Junior children should be answered if they are relevant. Their questions, however, are often very searching, and the teacher of Juniors needs to have a very wide background of general knowledge. The more interest one arouses, the more questions are asked! It is from thoughtful, pertinent questions that many projects arise. Sometimes the child can be set

to find the answer. But to return to "What is fur?"

Many people are ignorant of the difference between "fur" and "hair." The "fur" is what may be described as the "down" of a skin, and in many cases this down is protected by a much longer and stiffer covering called "hair." Horses and cows have no fur, only hair. In general, when an animal is only hair-covered, its skin is not used for fur. A cat has fur. The children will readily see the difference between the dog's hair and the cat's fur. They can be given specimens of wool to examine. In connection with wool and hair children find it interesting to collect pictures of all the wool-bearing or hair-bearing animals whose fibres are spun and woven. First they can collect different types of sheep in the British Isles—Scotch Blackface, Southdown sheep, etc. Postcards can often be bought. Then will come, perhaps, Australia. A useful booklet containing pictures of Merino sheep in Australia, sheep-shearing, fleeces, bales of wool, etc., can be obtained from Australia House, London, W.C.2. The collection grows slowly but surely. If careful notes are written under each picture, it adds to the interest and value of the collection. It must be a class project, as it is rarely possible to get enough pictures for individual collections. As the book grows, it is looked over by the children again and again, and much geography is learnt. A collection can also be made of different materials made from the fibres of animals—advertisements often help.

Cotton (*Plate XVIII*)

Having learnt about an animal fibre that clothes the world, the children are interested to learn about a vegetable fibre—cotton. The commonest material for clothing in the world is cotton. A great many people in the East dress in cotton—in Japan, China, Manchuria, etc. Cotton is also widely used for the simple garments of the village folk of Africa and India. The children can think of how many cotton things they wear, especially in the summer. They must also remember that cotton can be treated so that it resembles wool or silk; for example, velveteen, sateen, flannelette, blanket sheets, etc., are made of cotton.

Cotton is the soft, downy seed-covering of a plant that belongs to the hollyhock family. The little black seeds, not as big as lemon pips, are covered with beautiful white hair or fibre, varying in length from about half an inch to over two inches. A number of them are enclosed in round pods, called *bolls*, almost as big as eggs. When the pod is ripe it bursts open, showing the white, fluffy cotton down, or lint, in which the seeds are hidden (Plate XVIII). If left to itself, the down would be blown away by the wind carrying the seeds over the countryside. Cotton bushes are planted every spring and grow from two to three feet high.

It is worth spending some time to make sure that children know where cotton grows. Otherwise, in the fourth year, when they learn about the cotton towns of Lancashire, they are almost sure to say that cotton grows in Lancashire because it is damp there! Cotton grows best in warm climates with sufficient rain, but very little rain *in autumn*, when too much of it would spoil the lint or down in the bolls. The south-eastern United States have just the right climate for cotton—Texas,

Oklahoma, Mississippi, Alabama, and South Carolina, etc. In these states there is plenty of sunshine and enough rain. Plate XVIII shows a cotton-field in Texas. It must be explained to the children why negroes work in the cotton-fields in the Southern States of the U.S.A. They are the descendants of the African slaves. In the days of the slave trade, trading-ships captured negroes on the west coast of Africa and took them across the sea to North America. The settlers in the southern part of North America needed help for their tobacco plantations, and the negroes were able to work hard in the hot sunshine. The tobacco planters were willing to give a good price for slaves. The children will learn about the early colonists of North America in the history lessons.

Other important cotton-growing lands are India, Egypt, China, Peru, Mexico, Brazil, Russian Central Asia, and the Sudan, especially Nigeria and Uganda.

The U.S.A., being the greatest cotton-growing land in the world, is the best situated for cotton manufacturing. For a long time the New England States (Massachusetts, Connecticut, Rhode Island, Maine, Vermont, and New Hampshire) were the chief cotton-manufacturing regions of the United States, because they had water-power for electricity as well as plenty of coal. But now more cotton goods are being made in the mills of the south-eastern States than in New England. Montgomery, Augusta, Raleigh, Macon, and Columbus are examples of modern "Southern" cotton-manufacturing towns.

Great Britain has, of course, to buy all her cotton. She buys a great deal from the U.S.A. Make it clear to the children how cotton is brought to the Lancashire cotton-manufacturing towns. It is shipped in large bales from the following ports in the United States: Galveston (which exports more cotton than any other port in the world—from the "black prairie" lands of Texas), New Orleans and Mobile on the Gulf of Mexico, and from Savannah and Charleston on the Atlantic (Plate XVIII). The cotton-ships bring it to Liverpool or up the Manchester Ship Canal to the docks of the Port of Manchester (the docks are really in Salford!). There the bales are lifted out of the hold by powerful cranes and sent in lorry loads to the mills.

Cotton also comes to Lancashire from the Sudan and Egypt, from India, Brazil, Peru, and the West Indies. The children can find out more about cotton in *What the World Wears.* They will learn more about the cotton industry in Great Britain in the fourth year.

Rubber *(Plate XIX)*

Rubber is a topic of great interest to children. It seems like a fairy-tale that just the juice of a tree should give us our wet-weather clothing as well as a host of other things. Rubber is a native of the hot-wet forests of the Amazon in South America. The first European to see rubber was Columbus when he discovered the West Indies in 1492 and saw little brown children playing with balls of rubber.

Explain carefully how india-rubber got its name. It got the name of India because Columbus thought that he had come to India. It was called *rubber* because it was first used and valued in

Britain for rubbing out pencil marks on paper. It found its way to Britain about 1770; it was Priestley (the man who discovered oxygen) who found out that it would rub out pencil marks and called it "rubber." The Indian name for it was "caoutchouc," meaning "the tree that weeps." Nearly every language except English uses some form of the word *caoutchouc* (pronounced *how-tshōōk*) instead of the word "rubber." The first tiny cubes of rubber cost as much as 7*s.* 6*d.* each.

In their nature-study lessons the children will have learnt (or a special lesson can be given) about the common milk weeds that grow in England. These are small plants whose stems when broken give out a milky juice. In temperate climates these plants are small and rare, but in the tropics there are great trees that exude a milky juice when the bark is cut or damaged, or the leaves or twigs torn or broken. This milky juice is called *latex*. Impress upon the children that it is not the sap of the tree. The juice that pours forth from a cut is really for the purpose of healing the wound. It congeals over the cut. The West Indians discovered rubber by picking the soft lumps off broken twigs or damaged trunks.

There are a great variety of rubber trees, but the tree that gives the largest amount of rubber is the Hevea tree which grows in the hot-wet forests of the Amazon. It is some 50 feet high with a straight, smooth, greyish trunk which forks above into several boughs supporting an umbrella of dark-green oval leaves. Plate XIX shows a rubber plantation in Malaya. The children notice the slanting cuts made in the tree by the rubber-tappers. Tapping is done by removing a strip of bark with a tool shown on the inset (Plate XIX); the juice, or latex, flows down a spout (see inset) into a little cup. Men go around with pails into which the cups are emptied. The pails are then taken to the factory. The children can find out more about tapping the rubber trees, collecting the juice, and making rubber in *What the World Wears* (Harrap). They can read this book for themselves, and tell what they find out in class.

A useful four-page leaflet with a pictorial chart telling the story of Malayan rubber may be obtained from the Imperial Institute, South Kensington, London, S.W.7; also six picture postcards with an explanatory leaflet and map, at the cost of a few pence.

In the geography lesson it is important to show the children clearly where rubber grows. All rubber trees like damp air, heavy rainfall, and heat, so they only grow in the *hot-wet forests of the tropics*. The children can trace a rubber belt round the world keeping fairly close to the Equator. They begin with the Amazon region in Brazil, once the chief rubber-producing area of the world and a great source of wild rubber They follow the belt across the Atlantic to Africa, to the Congo forests; the Belgian Congo produces wild rubber. Crossing the Indian Ocean, they come to countries that have *rubber plantations* grown from seedlings. These cultivated trees are much superior to the wild trees of the Amazon or Congo, although it was from the trees of the Amazon that the first seedlings were obtained. The places famous for rubber plantations are Ceylon, Sumatra, Malaya, Java, Borneo, and Sarawak. These complete the rubber belt.

Flax *(Fig. 64)*

Flax will remind the children of their history lessons (see Volume II, HISTORY). Linen is perhaps the oldest of all the woven materials used for clothing, and it is still the best for strength. Long before cotton came to the British Isles and Europe, flax was grown there. A field of flax is quite different in appearance from a field of cotton. The flax plant is a slender plant about two or three feet high, with one main stalk, small narrow leaves, and very pretty blue flowers (Fig. 64). The seeds are planted close together because the closer the plants are made to grow, the finer and taller the stalks, and the better the flax fibres. These long fibres extend up and down the stalks. They are, of course, many times longer than cotton fibres, thicker and stronger. They are silky, but under the microscope one can see the surface is slightly rough. This rough surface fits them for spinning, as the fibres do not slip when twisted. Perhaps it was because of the length of the flax fibres that man began to twist them together to make a long strand before he discovered how to twist together the short fibres of wool or cotton.

Fig. 64.—FLAX.

Flax again differs from cotton in growing in the Cool Temperate Zone. Nearly all the flax of the world is now grown in the great plain of Northern Europe—which stretches across Northern France, Belgium, Germany, Poland, the Baltic States, Lithuania, Latvia, and across the U.S.S.R. about as far as Tomsk. Flax is also grown in Northern Ireland, and a little in Canada and Japan. Europe and the U.S.S.R. may be called the flax countries as the southern part of the United States is the cotton country.

Children should be told that flax is also grown for its seeds, from which a useful oil is obtained called linseed oil. Flax for clothing is grown in the cool temperate lands, but flax for oil is grown in the warmer lands, especially in India and Argentina, and also in the U.S.S.R. in Asia.

The children can read about the harvesting of flax, linen-manufacturing centres, the value of linen thread, etc., in *What the World Wears* (Harrap). In lessons on the British Isles, the children will learn about flax-growing in Northern Ireland. The greatest linen-manufacturing place in the world is still Ireland. The industry is carried on in Belfast, Londonderry, and the neighbouring small towns.

Other interesting topics are—silk, rayon, nylon, leather, boots and shoes, gloves, buttons, the story of the stocking, jewellery, hats, colours used to dye clothes, needles and pins, etc. For these other topics see *What the World Wears* (Harrap).

Projects and other Activities

Many projects arise in connection with lessons on "What the World Wears": (1) Interesting picture-books can be made; for example, (*a*) pictures of woollen garments of all kinds and of people wearing woollen garments in different parts of the world; the same can be done for cotton. In the case of cotton it must be remembered that

cotton can be treated so that it resembles *wool* or *silk*; for example, *velveteen and sateen* are made of cotton, and so is flannelette. Fabrics of mixed cotton and wool are also very common. (*b*) Pictures of all the animals that supply fibres for clothing, etc., sheep, goats, yaks, camels, alpacas, llamas, etc. (*c*) Pictures of creatures whose skins and hides provide the world with leather: cattle, horses, sheep, pigs, goats, deer, calves, lizards, crocodiles, etc. (*d*) Pictures of plants and insects that provide fibres for weaving: cotton plant, flax, coniferous trees (artificial silk), Manila hemp, Ramie grass or China grass from which grass cloths and grass linens are woven, fabrics that resemble both silk and linen and make beautiful dresses, silkworms, etc. (*e*) Pictures of people wearing clothes of different fashions—Eskimos, Chinese, Dutch, Negroes, etc.

(2) The children plan an exhibition of clothing material; they collect specimens of raw cotton (these can be obtained from the Imperial Institute, South Kensington), wool, flax, etc., pieces of leather of different kinds (these can often be obtained from shops dealing in leather, and cobblers, etc., and so on. Specimens of finished materials—linen, rayon, etc.—will be included, as well as raw material.

(3) Perhaps the project children most enjoy is making a complete list of the names of things made of rubber, adding pictures wherever possible. Tell the children that some rubber companies claim to make 50,000 different things of rubber. It is, of course, an impossible task for children to name them all, but they can aim first at twenty. Making this collection helps them to realize that we live in an Age of Rubber as well as an Age of Iron. They become more observant and, of course, quickly enlist the interest of father. Rubber tyres are probably first thought of, and the common rubber. It may help them if they think of (*a*) rubber in the streets; (*b*) rubber in the home—washers, anti-splash nozzles on the tap, rubber tyres, and buffers on the carpet-sweeper and vacuum cleaner, rubber mats, hot-water bottles, etc.; (*c*) rubber clothing; (*d*) rubber in sports and play—rubber tennis balls, tennis shoes, balloons, floating toys, rubber bathing-caps, water-wings, and a host of other articles; (*e*) rubber in school and office—rubber erasers, rubber date-stamps, elastic bands, the typewriter has a rubber-covered roller and rubber feet; (*f*) rubber in industry—these will not be familiar to the children—rubber washers, rubber hose and tubing; (*g*) hard rubber or ebonite—radio, telephones, domestic electrical fittings, pipe-stems, hair combs, fountain-pens, etc.

(4) *Country walks or visits.* Encourage the children when they are in the country to keep a list of any sheep they see and try to find out their names. In the south they may see the Southdown sheep, and in the north the Cheviots are a well-known breed. If they visit a town like Braintree, they may be able to find out something about the making of artificial silk or rayon. One wants to arouse in children interests that lie outside the school walls.

(5) Let the children examine a reel of cotton or thread, and write down all they notice about it. Why is there a hole in the middle? How is the end of the thread fastened when enough has been wound on a reel? How many

yards of cotton do you think there are on a reel? Some say 150 yards. On some there are 400 yards. Think of a thread of this length being twisted from cotton fibres less than two inches long! Measure a yard of thread.

(6) Let the children pull a piece of cotton-wool to pieces and notice the delicate fibres of cotton. Let them try to measure the length of a fibre, and draw a line about as long as a cotton fibre. They can do the same with a specimen of raw wool. The children can make interesting booklets of the story of cotton up to the time when the raw cotton is unpacked at a mill in Lancashire or up to the time when their mother buys a reel of cotton.

Correlation with other Subjects

Clothing forms a good centre of interest. The connection between clothing and history has already been touched upon and is obvious. In connection with arithmetic, children enjoy puzzles or problems like the following:

ARITHMETIC

(1) At the Sydney Wool Sale, Australia, 1,000,000 bales of wool were sold. If each bale weighs 300 lb., how many pounds of wool are sold? If the wool from 200 sheep weighs nearly one ton, what does the wool of one sheep weigh?

(2) A shearer in Australia was paid 35*s.* per hundred sheep. A good shearer often earned £14 a week. How many sheep does he shear in a week?

(3) It takes 7 lb. of *greasy* wool or $3\frac{1}{2}$ lb. of *clean* wool to make one suit of clothes. How many suits of clothes can be made from a bale of greasy wool (300 lb.)? How much clean wool does a manufacturer get from a bale of greasy wool?

(4) To feed enough silkworms to make one pound of silk 112 lb. of mulberry leaves are needed. How many mulberry leaves are needed to make a cwt. of silk?

(5) One pound of silkworm eggs when hatched will produce silkworms that need about 10 tons of fresh mulberry leaves. Supposing 500 tons of silkworm eggs were hatched in China (generally more than this are hatched), how many mulberry leaves are needed?

(6) Silk manufacture was introduced into England during the reign of Henry VI (1422–1461); but not much silk was made until skilled Flemish weavers fled to England in 1585 because of war with Spain. For about how many years has the silk industry been carried on in England?

(7) The world's population is estimated to be just over 2,000,000,000. Suppose a factory made 10,000 pairs of shoes a day, in how many days would it make enough for the whole world? In how many years? Remember it would then have given only one pair of shoes to each person.

LITERATURE AND ENGLISH

Interesting stories and legends about clothing easy enough for backward children to read will be found in *A Tale in Everything* (Univ. London Press); for example, "The First Pair of Shoes," "The Story of Flax," "The Fairy of the Cotton Plant" (this is a particularly fine legend from the cotton state of Alabama, U.S.A.), "The Story of the Silkworm." In *Round the World in Stories* (Univ. London Press) there are two easy stories—"The Travels of a Little Princess to the Land of Rubber," and "Little Wooden Shoes." Children enjoy collecting rhymes and stories

about clothing beginning with "Baa, baa, Blacksheep," and "Baby Bunting."

A very useful play about weaving will be found in *The Romance of Reading*, Book III, "Pleasant Paths." These easier stories help to arouse interest among backward readers and help spelling and vocabulary.

In the literature lessons (see Volume I), many fine stories can be told or read; for example: (1) Some Bible stories. The story of Abraham from the point of view of geography; Abraham's wealth consisted of sheep and goats. Jacob, too, was a shepherd; his meeting with Rachel at the well is a useful story. The shepherd lad, David; David and Goliath, etc. (2) Odysseus and the Giant Shepherd. (3) Penelope and her weaving. (4) Jason and the Golden Fleece. This story shows the value of wool in olden days. (5) But perhaps the finest sheep story is the extract from *Lorna Doone*, by R. D. Blackmore, about "The Great Winter." The story of how John Ridd dug out and saved the sheep that were buried in a snow drift is of absorbing interest to children. Every child should hear it before he leaves school. (6) The story of "The Flax," by Hans Andersen.

Children will also be encouraged to look for books in the Free Library. They may be able to find stories about fur-trappers, for example, R. M. Ballantyne's *The Young Fur-Traders*, or interesting books about animals in which they can look for fur-bearing, wool-bearing, and hair-bearing animals. They may, too, be able to find easy books about cotton, linen, or rubber, etc.; for example, *Rubber and its Many Uses*, by Herbert McKay (O.U.P.).

One must not forget the many poems about sheep, lambs, and shepherds, such as Anne Taylor's "The Sheep," William Blake's "The Shepherd," and "The Lamb." Many of these rhymes will be found in *Little Gem Poetry Book*, Books I–IV (Bell).

Such a course as outlined in this chapter should both *revise* and increase the child's vocabulary in a purposeful way and make him familiar with many useful and beautiful words. These can be collected in the English lessons and the child can make his own word-books in connection with the different topics. Words such as *fleece, loom, warp, weft, fabrics* (anything put together, especially woven material), *woven, bale, yarn* (any spun thread, especially thread prepared for weaving Just as one can spin a long rope or yarn, so one can tell a long story. A long story is often called a yarn. When travellers or people tell long or rambling stories they are said to "spin a yarn"), *sheepfold, pasture*, and so on. The same words used in the Scripture lesson, craft lesson, geography lessons, etc., really become part of a child's *thinking* vocabulary.

Suggestions for a project on *Robinson Crusoe* for teachers who like a project overflowing into all subjects: (1) *Geography*—a fair idea of a tropical environment, its plants, animal life, and weather can be built up through this story The children follow Crusoe's voyage on the map. His island is believed to be the island of Tobago, near Trinidad, at the mouth of the Orinoco River, South America (2) *Industrial and Social History*, see Chapters II and III, HISTORY. Each occupation and invention is seen in reference to human needs. Industries using the less resisting mediums developed first, such as

basketry, clay modelling, pottery spinning, and weaving. (3) The story therefore furnishes an excellent departure for the *Handwork* most suited for the Primary School. It places handwork in a setting of meaning (see Volume IV). (4) *Art.* There are many episodes that cry out for expression—Crusoe and his Parrot, Crusoe and the Footprint in the Sand, etc. (5) *Arithmetic.* Crusoe's Calendar, Calendars, Telling the Time, etc. (6) *English.* The teacher reads and tells the story in vivid episodes; the children make their own Robinson Crusoe books for reading, spelling, writing. (7) *Ethical training*—the patience with which Crusoe conquers difficulties. He is thrown into a situation where he must work or starve. After atoning for his idleness and thoughtlessness, he becomes an industrious, kind man, and is placed at last back among the comforts of his fellow-men and home. The story is a complete dramatic cycle.

CHAPTER TEN

MORE DETAILED STUDY OF THE HOMELAND

THE last year is a good year for a more detailed survey of the homeland (the British Isles or whatever the homeland may be) in connection with the world. As probably a detailed study of the continents will begin in the Secondary School, this course is quite a good preparation for Senior work. It also gives opportunities for making sure the children are familiar with all the marks and colours, etc., used on atlas maps. The following suggestions for a study of the homeland refer to the British Isles, but they can be adapted to any country.

The Position of the Homeland

The children already have some idea of this through their regional and world geography, but backward classes need revision. Making clear the position of the homeland is of first importance, and is sometimes neglected by young teachers, who are inclined to take it for granted that it is known to the children.

Great Britain is one of a group of islands, large and small, lying close to the western shores of the continent of Europe. These islands were once, very long ago, perhaps in the Age of the Cave-men, joined to Europe. They are generally regarded as part of Europe. Let the children notice that the British Isles are not in the Cold Lands or the Hot Lands but in the Temperate Lands north of the Equator. The children find out if the British Isles are nearer to the North Pole or to the Equator. Why is this important? They can run their fingers lightly northwards to see what lands and seas lie north of Great Britain. They do the same eastwards, southwards, and westwards. The size of the homeland in connection with other countries might be pointed out. Cf. Great Britain and Canada, or Great Britain and Brazil.

Direction Chart for the Homeland *(Fig. 65)*

By using a flat map of the world and laying their rulers in different directions across the British Isles, the children can find the direction (north, south, east, west) of a number of places from the British Isles. Draw a direction chart like that shown in Fig. 65 on the board for the children. Let the children check this chart by looking at their atlas map of the world and using their ruler or a strip of paper if necessary. Then they draw the direction chart (Fig. 65). Underneath they write in what directions these places are from the British Isles—Greenland, North America, South America, Africa, Australia, Europe, Asia, Norway and Sweden, Japan, etc.

Take this opportunity to make sure

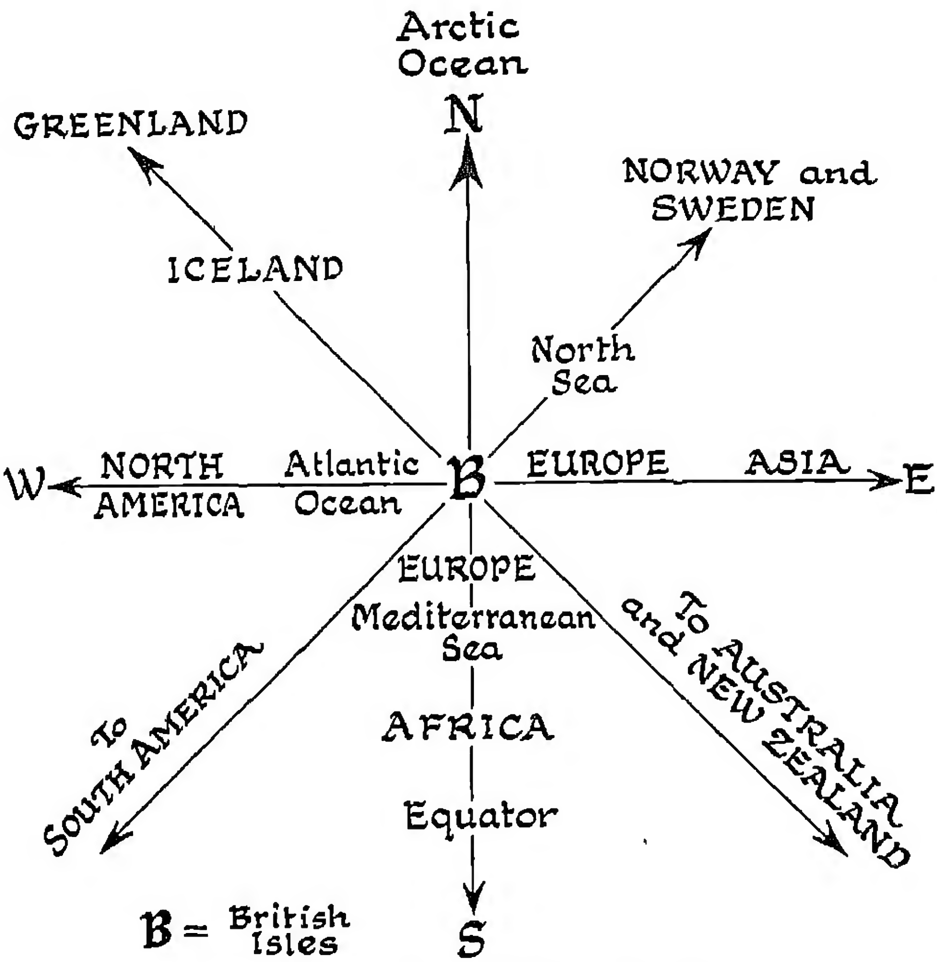


Fig. 65.—Direction Chart for the British Isles.

the children know the names of the six great stretches of land, or land masses, called continents, and the great oceans. They should know them, of course, but one must allow for ill-health, absences, and slowness.

The map now needs more careful study. Children have become fairly familiar with it because constant reference has been made to it in every class. An atlas should, however, not be used merely for identifying places. Encourage the children to be inquisitive enough to understand the significance of every mark and colouring on a simple map, and teach them to use the index intelligently. Much can be learnt about the map in studying the position of the British Isles or the home country.

The Sailor's Way of Describing the Position of the British Isles

The children already know two important lines on the atlas map and globe that cross each other—the Prime

or Greenwich Meridian and the Equator. Now draw their attention to the many lines on the globe. The Equator is a line of *latitude*. Parallel to the Equator other imaginary circles are drawn north and south. The lines of latitude are numbered from 0 at the Equator to 90 *north* at the North Pole, and 90 *south* at the South Pole. These lines help us to measure distances north and south from the Equator.

The meridians are called lines of *longitude*. They, too, are imaginary circles drawn round the earth, but they all pass through the North and South Poles and cross the lines of latitude. Lines of longitude help us to measure distances east or west of the Greenwich meridian, which is chosen as a starting-point for measuring. These lines are numbered from 0 to 180 each way. The 180 line is exactly on the opposite side of the earth to London. Meridian 180 is really the continuation of the Greenwich meridian, and is neither E. nor W. When we are noting the latitude of a place we mark it "N." or "S." to show whether it is north or south of the Equator. Longitude is marked "E." or "W." to show whether it is east or west of Greenwich.

Now let the children look at the atlas map of the British Isles and find the latitude and longitude of their town. Give them some places to find the latitude of, e.g. *Newcastle* is on parallel 55° N. (all lines of latitude are parallel); or we may say, if we like, it is in latitude 55° N., or that its distance from the Equator is 55° N. London is half-way between parallels 51° and 52°; it is in latitude 51½° N.

The children use the sailor's way of describing the position of the British Isles. Latitude 50° north just touches the south of England. It runs through the Lizard Head in Cornwall. A little way north of Scotland is latitude 60°. Thus the British Isles lie between latitudes 50° and 60° north. Let them find the longitude for themselves.

Latitude is always expressed in degrees for the convenience of seamen, but for ordinary people it would be easier to understand if it were expressed in miles, one degree of latitude being roughly 70 miles. Let the children find the latitude of several important places—Liverpool, Manchester, Birmingham, Bristol, Reading, Exeter. Ask them what towns lie in or near certain latitudes: 54° N., 52° N., 53° N., 51° N., 54½° N.

Exercises with the Globe or Atlas Map of the World

(1) The Tropics are 23½° from the Equator. Let the children write down the latitude of the Tropic of Cancer (23½° N.) and the latitude of the Tropic of Capricorn (23½° S.). What is the width of the Tropics (or Torrid Zone) in degrees from north to south? About how many miles is this? (2) What, roughly, is the latitude of their school? What other places in the world are the same distance from the Equator? (3) About how many miles is it from the Lizard to the Shetlands? (4) Through what continents, countries, seas, and towns does parallel 60° pass? (5) What places in the world lie in the same latitude as the Lizard? (6) Through what countries and seas does latitude or parallel 40° pass? (7) What do we mean when we say that New York and Lisbon are roughly in the same latitude? Find out from the map of the world what their latitude is (8) Find out which places in the Southern Hemisphere are

the same distance from the Equator as the British Isles, that is, between 50° and 60°? (This helps children to realize how little land there is in the Southern Hemisphere, and why New Zealand is warmer than the British Isles.)

LINES OF LONGITUDE

Let the children look at the lines of longitude on a map of England and Wales. They have been drawn at every degree. Thus the longitude of Reading is 1° W., *because it is the first meridian* west of Greenwich; the longitude of Liverpool is 3° W., because it is on the *third meridian west of* Greenwich. Boston, due north of Greenwich, is on the Greenwich meridian; its longitude is therefore 0°. Yarmouth lies in $1\frac{3}{4}$° east longitude.

From the map let the children find the longitude of York, Liverpool, Fishguard, Coventry, Falmouth, Carlisle. Which towns of England and Wales have, *roughly*, these longitudes: 1° W., $1\frac{1}{2}$° E., $1\frac{1}{2}$° W., $3\frac{1}{2}$° W.?

On the globe and atlas map of the world, the children find through which continents, countries, and oceans each of the following meridians pass: 0°, 180°, 90° E., 90° W.

FINDING THE MOST EASTERN COUNTIES IN ENGLAND

This is an easy and useful exercise for dull children. They find the north-south line on their maps that passes through London, the prime meridian. They notice how much land juts out into the sea to the east of this line by placing their ruler along it. They move their ruler on to the next meridian, 1° E., and find what counties now project beyond the ruler. Parts of Norfolk and Suffolk and a little bit of Essex and Kent. They move their ruler along, carefully keeping it straight, until the only counties to be seen are Norfolk and Suffolk. These are the most easterly counties of England, and they are fittingly called East Anglia (see HISTORY, *Volume II*). Essex is often included in East Anglia, as it is the same type of country. The children move their ruler still farther east and find the most eastern point of land in England—Lowestoft. Lowestoft is a very little farther east than Yarmouth —both Yarmouth and Lowestoft lie in about $1\frac{3}{4}$° east longitude. The children find the most westerly part of Great Britain—Land's End. About what longitude is Land's End?

This question interests children very much, especially A children. Which is farther west, Liverpool or Edinburgh? They find the two places on their map of the British Isles. Since Edinburgh is on the east coast and Liverpool on the west, most children at once declare that Liverpool is farther west. Their ruler will prove that Edinburgh is farther west.

If all the meridians were put in, that is, if they were drawn at every degree, there would be 360 of them, since there are 360 degrees in a circle. As they would crowd the map too much, some are left out. At the Equator the meridians are about seventy miles apart, but the children will see that as we follow them towards the poles they get closer and closer together, until at parallel 60° there is only half seventy miles between them. After that they converge rapidly and all meet at the poles. We cannot, therefore, give the longitude of a place in miles from the Greenwich meridian. On the map of England and Wales in their atlas let the children

measure the distance between the two meridians along the northern edge and compare it with the distance between two meridians farther south.

Give the children plenty of opportunities during the year of using the index at the end of the atlas. Begin with one or two easy towns, such as the town of Boston in Lincolnshire. It lies on latitude 53° N. and longitude 0.

Longitude and Time, or Time Round the World

Some teachers may like to tell the children how time varies as we travel round the world eastward or westward. Meridians are *time-lines*. If we travel along a meridian from north to south, our watch always shows the same time. The clocks at all places on the same meridian always show the same time. On the other hand, if many meridians are crossed, our watches have to be altered every day. The sun travels round the world over the 360 meridians in twenty-four hours, that is, 15° in one hour, or 1° in four minutes. Since Reading is on meridian 1° W., the noon sun reaches it four minutes after passing the Greenwich meridian. In the same way Liverpool, on meridian 3° W., has noon twelve minutes after Greenwich. Once each town kept its own local time, but with the coming of punctual trains, telegrams, telephones, etc., this proved very inconvenient, and so now all Britain keeps Greenwich Time.

Children interested in how time differs on the different meridians, and how sailors find latitude and longitude at sea will find help in *Projects for the Junior School,* Book IV, Chapter VII (Harrap).

Exploring the Map of England and Wales; Finding One's County

Let the children study both a relief map of England and Wales and a map showing the counties, to make sure they understand every symbol and colour on the map. Begin with a map showing the counties. Remind them again that it is the custom to put north at the top of the map rather than to put south. If the children have learnt to box the compass (Chapter II), they will know where east and west come. If not, teach them to name the points in the right order sun-wise or clock-wise, N., E., S., W. In the case of slow children, let them sometimes, if possible, move their desks so that N. on the atlas points to the true north.

Through drawing maps, studying the Ordnance Survey maps, and their arithmetic lessons, the children should be fairly familiar with scales. Point out to them the scales on their atlas maps. The scale is shown in two ways:

(1) By a statement: Scale 1 inch to 3,000,000 inches, or shortly 1 : 3,000,000. The scale of 1 inch to 3,000,000 inches is useful and often found on maps. It is an easy scale because 1,000,000 inches is approximately 16 miles.

(2) By a line: A line is drawn to represent, for example, 10, 20, 30, 40, 50 miles. Let the children study the lines in their atlases. By marking the length of the line on a strip of paper they can measure the distances between any places on their maps. Opportunities for doing this should be given to the children from time to time (see the coming section).

Map of a County (Fig. 66)

The child finds the village (or nearest town to the village) where he lives, and

his county. He describes the position of his county. (The children soon see how the counties are distinguished on the map.) Is it by the sea? In the north? etc. The counties bordering the home county are named. Children are interested in the different sizes and shapes of the counties. In England the largest county is Yorkshire and the smallest Rutland. Later the children will learn about their County Council and its work; how it looks after the affairs of the county—schools, roads, hospitals, and many things. Each child makes a tracing or drawing of the county, as in Fig. 66. The county town, and the nearest large town to the children's homes, are also put in, and any other very large towns. Finally they put a dot to show roughly where they live.

By using the scale line on their atlas map (the line represents 50 miles), they can measure the width of their county from E. to W., and from N. to S. They mark off on the edge of a strip of stiff paper the length of the scale line, and the five parts into which it is divided, each of which represents ten miles. With this strip they measure their county from E. to W., and from N. to S. There are other distances the children will like to find—how far their town is from London as the crow flies, or from the sea, or from another town. How long England is from north to south, from Berwick-on-Tweed to Portland Bill, etc. The children, with the

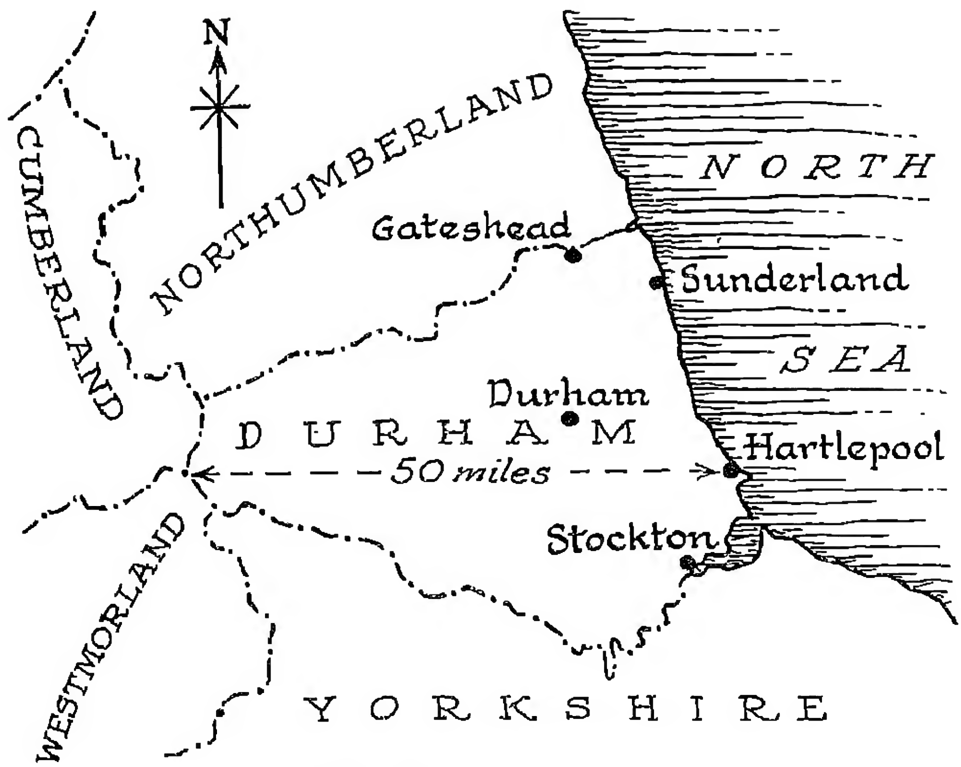


Fig. 66.—Map of County of Durham

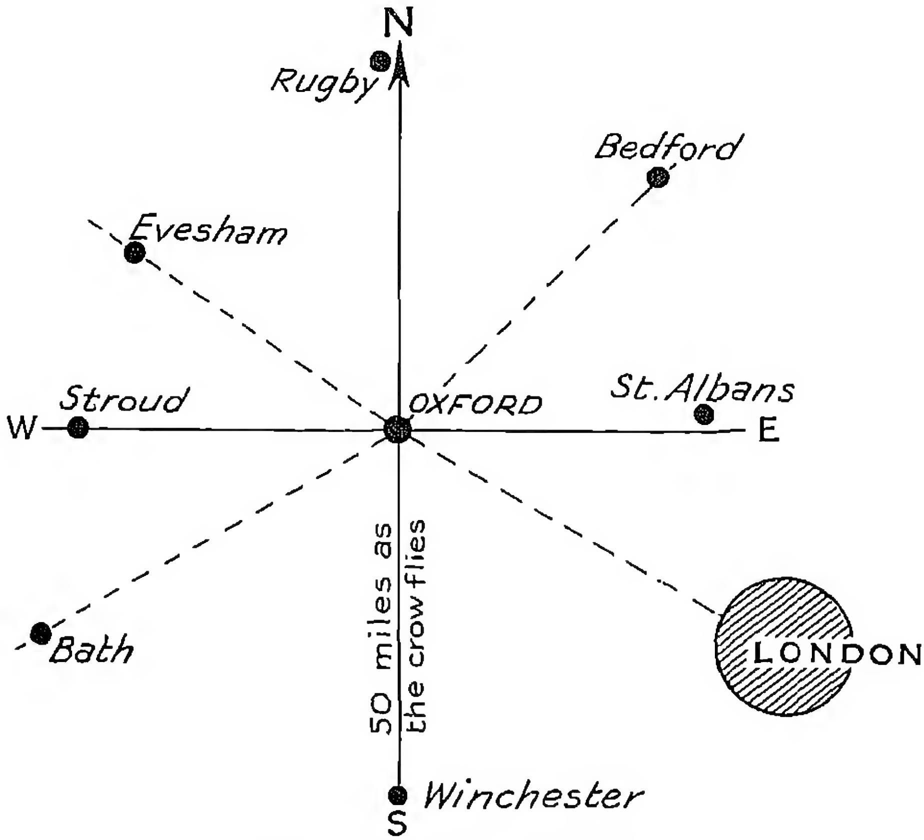


Fig 67.—Direction Chart for Oxford.

help of their map, draw a direction chart for the places near their town or village. Their ruler or a strip of paper will help them to find places due north or south, etc. Fig. 67 shows a direction chart for Oxford that can be drawn on the board for the children to verify with their atlas. Underneath they write the direction that each place lies from Oxford—thus Rugby, N. of Oxford, Bedford N.E., and so on. They may not be able to find Stroud, as it is a small place and not marked on all maps. They make a similar chart for their town, and write on it the distance of each place from their own, using their line scale as before.

There are many more things the children can discover about the town and district in which they live (see Chapters V and VI). The study of the Ordnance Survey maps will help them (Chapter V). If they live in a village, they can find their village on these maps and trace the boundary of their parish, etc. The study of their own district may in certain cases take some time and go on throughout the term or year. Self-help booklets may be made about their town and county, the title, for example, being, "The Village of Ash, near Canterbury, in the County of Kent," or "The Town of Bolton in Lancashire." Pictures can be found for these book

lets—pictures of important buildings in the town, or beauty spots near, etc. Many facts may be collected, such as the number of people in the town, occupations, factories, shops, source of the supply of coal and water, etc.

The General Build of Great Britain

The next step is to get the children to understand the general build of Great Britain by exploring the mountains, uplands, and hills. The children have already learnt something about the hills and mountains in their own district (see Chapter V). Now they pretend to take flights in an aeroplane over England and Wales, to get what is called a bird's-eye view of the country and see where the mountains and lowlands are.

They prepare for the journey by looking at a *relief* map of England and Wales. They study the key in the corner of the map and make sure they know what all the colours mean. Flying across the country from west to east, and north to south, it can be seen that the highlands are mainly in the north and west, and the lowlands in the east.

First they find the great block of highlands in the north of England which extend into Scotland, where they are known as the Southern Uplands. The part of this block of highlands that forms the boundary between England and Scotland is known as the Cheviot Hills; the part that extends through England southwards to the River Trent is called the Pennine Chain or the Pennine Uplands. Uplands or moors are, indeed, better names than *chain*, because the Pennines are too broad for a chain. They are a high, wide *tableland* of moors covered with heather and thin grass. None of the peaks is very high. The children can find the heights, spot heights, of some of the peaks on the map; for example, Cross Fell, the highest, is 2,930 feet. The children will see that the Pennines form a distinct water-parting or watershed between eastern and western England. They notice the difference between the rivers flowing west and the rivers flowing east. Which are shorter, and why? The children find the river valleys (Chapter VI). One cannot talk about mountains without mentioning rivers.

Remind the children again that rain which falls on the roof of a house is bound to run down one slope or the other until it reaches the gutters, so the water that falls on the mountains is bound to run down one side or the other and cut itself valleys or gutters (Chapter VI). Joined to the Pennine Range on the west by a moor or plateau (tableland), 1,000 feet high, are the Cumbrian Mountains, so called after the county they are in, Cumberland. The children find the three highest peaks of the Cumbrian Mountains. From this grand cluster of peaks, woody slopes and heather moors, streams flow down to the loveliest lakes in England; this part of the country is known as the Lake District. Now let the children take an imaginary flight over the Pennines from north to south; starting from the Cheviot Hills in the north and ending in the Valley of the Dove. Let the children tell what they will see. They may need some help. They may mention the Tyne Valley and Cross Fell. Tell them that from Cross Fell one can look across the lovely Eden Valley to the Cumbrian Mountains. Be sure they notice the important gap in these uplands, formed by the River Aire, and known as the

Aire Gap, just as the gap across these uplands made by the River Tyne is called the Tyne Gap. Point out, too, the Peak, the centre of the lovely Peak District in Derbyshire, and the valleys of the Dove and Derwent streams that flow into the River Trent. Here the Pennines end.

From the Pennines the children can fly across the Cheshire plain to the mountains of Wales, the Cambrian Mountains. Here the children can find Snowdon, so called because its peak is often covered with snow, Cader Idris and Plynlimmon with their connecting lines of hills and uplands and a *few* large and lovely valleys. The mountains run close to the sea, forming a magnificent line of cliffs. The children will be able to say why there are no *long* rivers in Wales flowing westwards.

Pictures are needed to make these mountains come alive; many guide-books contain useful pictures, and pictures of Scafell, the Lake District, the Peak District, Snowdon, etc., are fairly easy to obtain. It is often necessary and helpful when children are studying the general build of England and Wales to have a relief *model* to use side by side with the relief map. On the relief model even the dullest child can see where the highlands lie, and where the lowlands and plains are. One must remember, however, that the use of the relief model is to teach children to interpret maps; when once this power has been acquired the model is unnecessary and indeed a hindrance. In some schools, and especially in A classes where children have become accustomed to map-reading and to reading and understanding contours, the relief model may be dispensed with. A few teachers seem to think a relief model is always necessary.

The children can explore the remaining moors and uplands in much the same way. In the south-west are the high moorlands of Dartmoor, Exmoor, and the Cornish Heights. The children can find the highest part of each of these three uplands and write down their heights—Dunkery Beacon, Exmoor; Yes Tor, Dartmoor; Brown Willy, Bodmin Moors, Cornwall. The children have now found all the mountains and highest moors and tablelands in England and Wales. Tell them that if a line were drawn from Start Point to Flamborough Head all the highest mountains and moorlands lie west of it. They can prove this by placing their ruler on the map in the position of the line described.

Hills

The children will be interested now in finding the hills. Few heights are given in the atlas for hills, as they are generally below 1,000 feet. Many hills are, of course, not shown. It must be impressed upon children that no part of England is absolutely flat; everywhere there are hills and the land rises and falls gently. This is one of the charms of England. But these gentle hills cannot be shown on atlas maps of England, though they may be on Ordnance Survey maps which show only a very small part of England.

There are two distinct lines of hills crossing England from the south-west to the north-east. The children can pretend to find them in their aeroplane. The first line of hills begins as the Cotswolds, then almost disappears until it is seen again as Edge Hill (716 feet). Then it disappears again

until we pass the rivers that flow into the Wash; then it stands out boldly as the North Yorkshire moors. We can follow a second line of still lower hills, gently rounded chalk hills covered with grass that form the low tableland of Salisbury Plain. These hills cross east as the Chiltern Hills, and then go on to form the East Anglian Heights, the Lincolnshire Wolds, the Yorkshire Wolds, and end up in the fine outstanding cliff of Flamborough Head. From Salisbury Plain extend two other low chalk ranges, the North Downs running to Dover and forming the white cliffs of Dover, and the South Downs running into the sea and forming Beachy Head.

The Southern Uplands, the Central Lowlands, and the Highlands of Scotland can be explored in the same way. Again pictures help. Illustrated guides can be obtained from railway companies and famous holiday resorts in the Highlands. The pictures can be cut out and mounted, but some booklets should be kept intact to form part of the Geography Library.

Other Imaginary Journeys

These can be taken by means of railway guides, pictures and descriptions, so that the children learn to find their way about the home country, for each of the places chosen can be reached by the best route from the school. The following are suggested journeys of different kinds:

(1) Railway Journeys

The children should be familiar with the four great railway systems. The relation of each great main route to the chief features of surface relief may be brought out in class discussion. Junior children can see quite well why the east-coast route into Scotland is an easier way from the point of view of the railway engineer than either of the main west-coast routes.

(*a*) A railway journey from London to Penzance on the Western Region Railway. Railway Guides often contain useful maps and pictures. The children themselves can make their own picture-booklets (Fig. 68) in which are pictures and descriptions of some of the interesting places passed. These booklets may be group work. Each child in the group or class writes an interesting account of things seen from the carriage window. They are read in class and then made into a panorama booklet. Here is the outline of a Travel Book made by nine-year-olds· (1) Paddington Station. (2) The glimpse of Windsor Castle seen from the window and a few sentences about it. (3) Busy Reading and its biscuits. (4) Newbury and its racecourse. (5) The Wiltshire White Horses, especially the Westbury White Horse carved on the Wiltshire Downs to the south-east of the town. (6) Frome on the borders of Somersetshire, famous for its woollens. (7) The journey through Somersetshire with its wide green meadows, cows and apple orchards. (8) Taunton, the county town, and so into Devonshire. (9) The journey through Devonshire with its red soil and red cattle feeding in green fields, and orchards. (10) The old town of Exeter and its famous Cathedral. (11) The journey from Exeter past Dawlish and Teignmouth to quaint little Totnes with the train running close to the sea. One child described a high tide, a rough sea, and waves dashing over the carriages! (12) Plymouth with its memories of Drake. (13) Crossing the Tamar into

Cornwall by the Royal Albert Bridge, a wonderful arch and suspension bridge built by the famous engineer, I. K. Brunnel, in 1859. (14) The China Clay works of Cornwall. (15) Truro and its cathedral. (16) Camborne and its tin mines. (17) Marazion and Penzance.

(*b*) A railway journey on the Eastern Regional Railway from King's Cross to Berwick-on-Tweed. This long railway line—the east-coast route into Scotland—goes on to Edinburgh, then across the Forth and Tay bridges to Dundee, and on northwards to the granite city of Aberdeen. Most children want to go on to Aberdeen! A sketch-map of the journey may be put on the board for the children (Fig. 69), and it can be drawn by the children themselves. It is easy for them to draw the east coast and the railway line if they first draw the three meridians 2, 1, 0, and the lines of latitude 51, 52, 53, 54, 55, 56. The children will see clearly why the east-coast route into Scotland is an easy railway route to build. They can compare it with the west-coast route through Carlisle.

(*c*) Other interesting railway journeys are from London to North Wales through the Midland Gap to Chester and along the coast to Anglesey, or from London to South Wales through the Severn Tunnel to Cardiff, Swansea, and Fishguard.

The railway system of Great Britain is organized into six regions: (1) The London Midland Region, with headquarters at Euston, which corresponds with the old L.M.S. system in England and Wales. (2) The Western Region, headquarters Paddington, the successor of the G.W.R. (3) The Southern Region, headquarters Waterloo, which does the

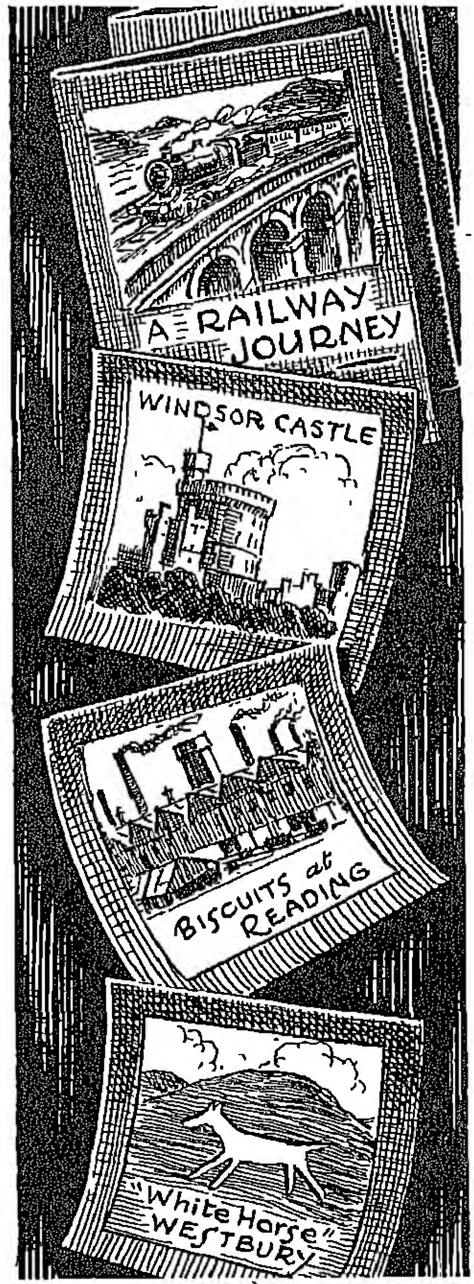


Fig 68.—A JOURNEY FROM LONDON TO PENZANCE.

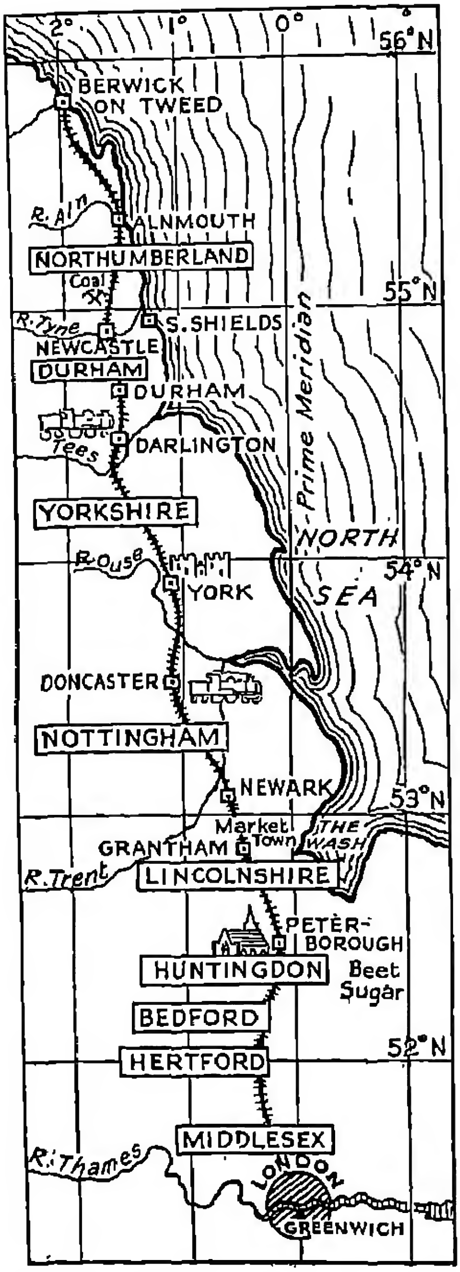


Fig. 69.—A Railway Journey from London to Berwick-on-Tweed.

work of the old Southern Railway. (4) The Eastern Region, with headquarters at Liverpool Street, corresponding to the southern area of the L.N.E.R. (5) The North-Eastern Region, with headquarters at York; and (6) The Scottish Region, operating from Glasgow.

Many railways radiate from London. A rough sketch-map may be drawn showing the routes from London (Fig. 70). Intelligent children will be interested to see how the railway lines get out of the Thames basin. They can look for the gaps and the gap towns on the broken rim of chalk hills that borders the London basin on all sides except the east, where it is open to the sea.

In connection with their railway journeys the children enjoy collecting pictures of bridges for a "Booklet about Bridges." Tunnels also can be included, for rivers are crossed by tunnels as well as by bridges. Their booklets should include pictures if possible, but in any case short written descriptions of wonderful bridges and tunnels, such as the Forth Bridge, the Tay Bridge, Saltash Bridge, the Menin Bridge, and the Severn Tunnel, Woodhead Tunnel, and the Box Tunnel. For projects about bridges see *Projects for the Junior School*, Book III (Harrap).

(2) Journeys by Motor

Many interesting motor tours can be planned, along the Great North Road from London, the Bath Road, and other famous roads. These motor tours make good projects. Suggestions for carrying out such projects, and lists of famous roads, etc., will be found in *Projects for the Junior School*, Book IV, Chapter II, "The Open Road" (Harrap). These

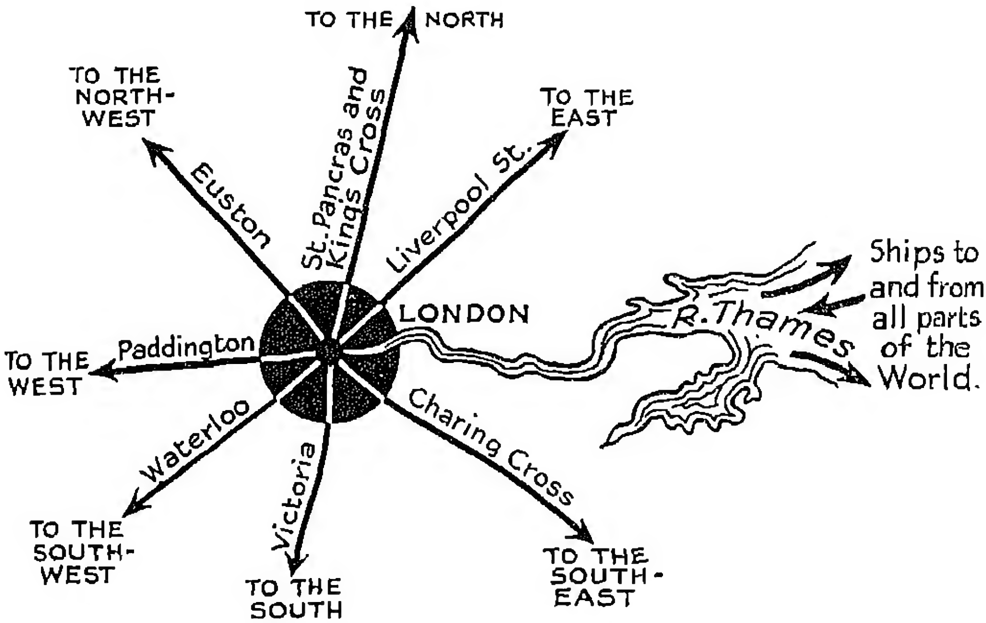


Fig. 70.—Main Railway Routes from London.

lessons emphasize the growing importance of roads. The children should also be encouraged to describe accurately any motor tours they have been, and make little booklets about them.

(3) Coastal Routes by Steamer (Plate XX) are of value because they give the teacher opportunities of describing or drawing children's attention to different types of coastline. A log-book is made, say, for a journey along the east coast from London to Aberdeen or from Berwick-on-Tweed to Dover, or along the south coast. In their rough note-books the children put down some of the things they are to notice or try to find—what the coast is like, high or low, rocky, sandy, muddy. The harder rocks that stand out alone in the sea are called *capes, headlands, points*. They look out for the names *Naze* or *Ness* (meaning *nose*) on their map journey. The children will guess why some capes are called *heads* and some *points*. They look out also for openings in the coast, *bays* and river *mouths*, also fishing-ports, lighthouses (Bamborough, Flamborough, etc.). They collect pictures of coast scenes from guide-books, and post-cards to illustrate their journey, also pictures of ships and boats. A collier (a boat carrying coal from Newcastle) is sure to be seen on the east coast, also a train ferry that carries loaded railway trucks across the North Sea from Harwich to Zeebrugge in Belgium (Fig. 74). Plate XX shows some examples of coast scenery. The children can contrast the granite cliffs of Cornwall with the chalk cliffs of south-eastern England, or the muddy shores of the Thames estuary. They write descriptions of the pictures on Plate XX, and tell stories about them.

(4) CANALS are of great interest, and an imaginary journey from London to Birmingham or from the Midlands to Liverpool is of value. The canals introduce the children to the Midlands. The Midlands are part of a plain, the English Plain, that has the Pennines on the north, the Welsh mountains on the west, and on the south and east low lime-stone hills, the Cotswolds, etc. An interesting booklet about the Grand Union Canal, containing pictures of canals, barges, locks, and maps, is issued by the Grand Union Canal Company, Port of London Building, Seething Lane, London, E.C.3. Transport by canal, though *slow*, is cheap, so heavy and bulky goods, such as coal, chalk, clay, sand, hardware, grain, oil, etc., are often carried by barges. There are many famous factories on the banks of canals, margarine factories, paper-mills, cement works, factories making jam, cocoa, gramophone records, etc. These factories need coal and raw material. On a journey from London to Birmingham, many factories with well-known names will be passed—at Harlesden, Heinz & Co. have one of the finest factories in Europe. The various things they need for their many food products are taken to their factory by barges loaded from sea-going vessels in the River Thames or in the Regent Canal Dock. There are Lyons & Co., Quaker Oats, Ltd., the Ovaltine factory, and many others. Fig. 71 shows a typical barge. It is long and rather low, but *deep enough* to carry a good load, well protected from the weather by tarpaulins. Fig. 72 shows a useful map of the canals. The children notice how the canals join up the rivers, and how Birmingham is connected with the sea on the S.E. (Thames), on the S.W. (Bristol channel), on the N.W. (the Dee, etc.), and the N.E. (mouth of Humber and Wash). Raw cocoa can come all the way by sea from West Africa to the Bristol Channel, then by river and canal to Cadbury Works, Birmingham. The whole journey is by water. China clay from Cornwall often goes by ship to Liverpool, then by canal to the Potteries. Children notice especially the canals that join the east and west coast—Goole and Liverpool.

(5) Journeys up or down rivers are of great interest to children; for example, journeys down the Thames, Avon, Clyde, or Shannon (see Chapter VI).

(6) Interesting journeys by road, rail, or steamer may be made to beauty spots and holiday resorts; for example, East Anglia or the Norfolk Broads, the Lake District, the Highlands of Scotland, the Lakes of Killarney, etc.

Whatever places are visited, they should be linked where possible with something already learnt; for example, if the children are exploring East Anglia and visit Cromer, tell them that the air coming from the north to Cromer is said to be the purest and freshest air in England because there is no land between the North Pole and Cromer. Let the children look at the globe and see if this is really true. At Cromer, too, one can see a sight that is rare on the east coast—the sun rising from and setting in the sea. Again the children can look at their map to explain this.

Industries of the British Isles

(1) FARMING (this will introduce weather and climate).

Farms have been dealt with in connection with the first year's work, Homes, and in particular in the second

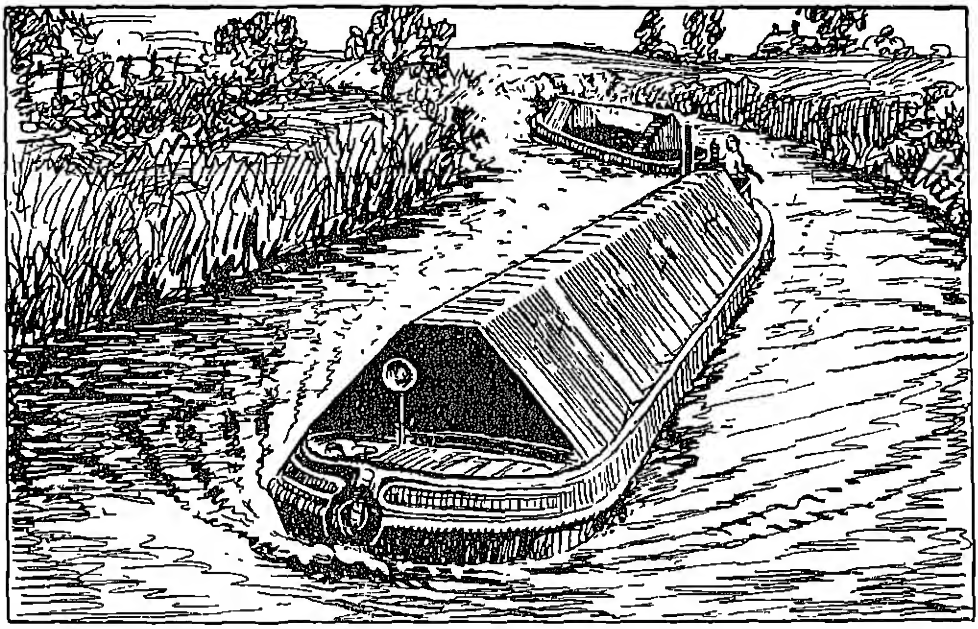


FIG. 71.—DIESEL-ENGINE-DRIVEN BARGE ON CANAL.

year in connection with "What the World Eats." Farms (especially the story of milk) are also dealt with in the nature study section (Volume IV, in Fourth Year's Work in Nature Study), so not much time need be spent over farming. The various kinds of farming can be considered and the parts of the British Isles most suited for each, (*a*) Fruit, (*b*) Dairy Farming, (*c*) Corn, (*d*) Sheep, (*e*) Mixed Farming, (*f*) Market Gardening. This leads to a consideration of the weather and the nature of the soil. Throughout the whole course weather has not been neglected, and weather charts of different kinds have been kept. The following questions have arisen from time to time and been answered. Which parts of Britain are warmest in the summer? Why? Why do some people go to Torquay or a place on the south coast in winter? Where does the snow lie longest in Britain? etc. Why is wheat grown in East Anglia? Where are most sheep found in the British Isles, and why? etc. Revise again the wet and dry winds of Britain. This will help children to know where different kinds of farms are.

On the west of the British Isles lies the broad Atlantic Ocean. Remind the children that winds that blow over the sea pick up water in the form of water vapour. Most of the winds that blow over the British Isles come from the west or the south-west, therefore they are moisture-bearing winds. When they reach the highlands of western Britain, for example the Pennines and the Welsh Mountains, they are forced to rise, the air expands and becomes cooler. It cannot hold so much moisture, and rain begins to fall. It is because of the wet winds and the high mountains that the English Lake District is the wettest part of Britain.

When the west winds have passed over the mountains and uplands and reached the plains of eastern England they have got rid of much of their water vapour and are fairly dry winds. The winds that blow from the east, the easterly winds, are much drier than the westerlies, for they come across the land of Europe, and although they gather up some moisture from the North Sea, it is not nearly so much as the west winds gather from the Atlantic. Moreover, the eastern side of Britain has no mountains, so there is very little high land to cause the air to rise.

The children look at the rainfall map in their atlas (W. and A. K. Johnston's School Atlas of Great Britain and Ireland). They will see why Ireland gets even more rain than Britain.

The word *climate* may now be explained. We have different weather from day to day, but each season we know, roughly, what weather to expect. The general weather for the year, season by season, is very much the

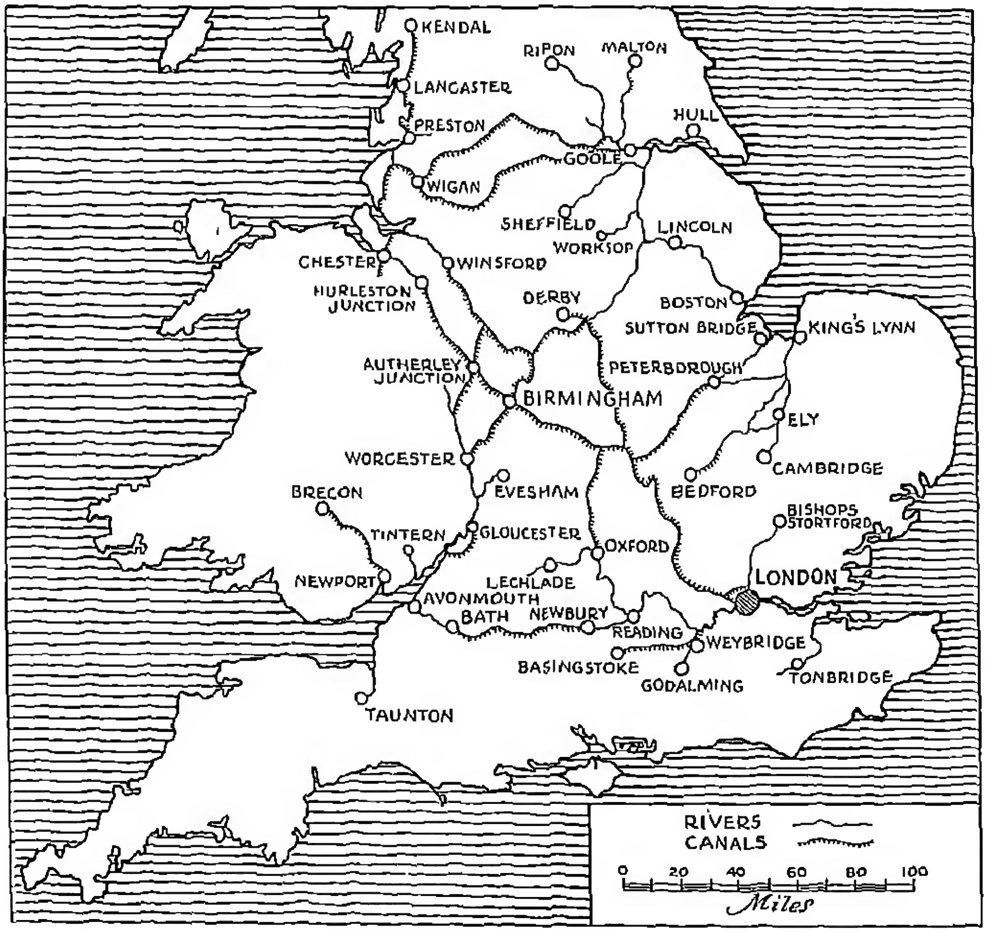


Fig. 72.—Map showing Canals.

same, though some years may be colder than others, and some drier. When we talk about the usual *yearly* weather of any country we are talking about its climate: "Weather for a week, climate for a number of years." The climate of Britain is one of rather mild winters, and summers that are not too hot. Rain may fall *in any month* in the year, but more falls as a rule in the winter half than in the summer half. The climate of Britain is a moderate or temperate climate, rarely too hot or too cold. The children will remember the climate of the equatorial forest lands—rain and hot sunshine all the year round, and the lands where rain falls only at certain seasons (the monsoon lands).

The connection between farming and weather is obvious. Wheat grows best where there is not too much rain and plenty of sun to ripen it, as in East Anglia. Wales is too wet for much wheat-growing; Scotland on the whole is too cold, so oats and barley are common, but wheat grows in the warmer and drier eastern parts of the Scottish Lowlands. Ireland, again, grows more oats and barley than wheat, because oats and barley can stand the damp better than wheat. Sheep like short, sweet grass such as grows on uplands like the chalk hills of south-eastern England, the Downs, the drier slopes of the Welsh Highlands, the Pennines, the Cheviots, and the Southern Uplands of Scotland. Cattle, on the other hand, need longer grass that grows in meadows by rivers, in the rich, moist valleys of Devonshire and in well-watered grassy plains like those of the Midlands. We find, therefore, dairy farming is especially popular in Devonshire and the Midlands. Nearly all farms keep some cows; and pigs and poultry are reared almost everywhere, but especially in regions where dairy farming is carried on, and in others where grain is largely grown. Pigs can live well on the waste of dairy farming; for example, skimmed milk; poultry thrive on grain-growing farms.

A class-book can be made of farms in different parts of the British Isles (*Other People's Houses* has pictures of some small farms), and pictures found not only of farms, but of occupations on the farm. (See Plate XX, NATURE STUDY.) The children will have learnt a good deal about the planting and harvesting of wheat, both in their second year's work and in their history lessons (see Volume II). The making of such a class-book or booklets is especially useful for backward children. Some children may like to group their farms under headings either according to their position—(*a*) Farms in Northern Ireland, (*b*) Farms in Southern Ireland, (*c*) Farms in East Anglia (*wheat, beet, mustard*, etc.); or according to what they chiefly produce, as (*a*) Fruit Farms—the orchard lands of Kent, Essex, Devon, Hereford, Warwick, the Carse o' Gowrie and the eastern lowlands of Scotland. The orchards of Devonshire can be contrasted with the soft-fruit lands of the Fen District (Cambridge, etc.). (*b*) Potato crops—the potato lands of Lancashire, Scotland, Ireland, etc.

It must be impressed upon children that the British Isles do not grow nearly enough food to feed all the people and that the great bulk of our food comes from over the seas. Without our ships and money to buy food from other lands we should starve. (See pages 139, 140, 141.)

(2) THE FISHING INDUSTRY

This is a very important industry. It has been dealt with in the second year. The fishing ports can now be revised. (*a*) On the east coast: Wick, Fraserhead, Peterhead, Aberdeen, Whitby, Hull, Grimsby, Yarmouth, Lowestoft. From Hull, Grimsby, and Aberdeen steam trawlers go far looking for valuable deep-sea fish—haddock, hake, plaice, soles, etc. Lowestoft and Yarmouth are famous for herring fishing. (*b*) On the south coast: Brixham and Falmouth. (*c*) On the west coast: St. Ives, Fishguard, Fleetwood, etc.

(3) COAL-MINING (Plate XXI)

Children should find on the map the chief coalfields, and notice that in England they lie mainly on the flanks of the Pennines and in the Midlands. Smaller ones are in Somerset and in Kent (the newest of all). In Wales the main area is the South Wales coalfield. The largest coalfield in England is the great Yorkshire, Derbyshire, Nottinghamshire coalfield, extending from Leeds to Derby and Nottingham; the South Wales coalfield is about as large as the largest English one. In Scotland the three coalfields lie in the Lowlands, where most Scots live today: the coalfields are the Ayr, the Lanark, and the Firth of Forth. In Ireland there is very little coal. Let the children notice that wherever there is a coalfield there is a cluster of important towns. They can almost give the position of the coalfields from the towns. Without going into tiresome details, the children should know something about the work done in the coalmines and the life of the miners, so that they appreciate the dangers and difficulties of their work. Plate XXI will help. Here they can see the winding gear for lowering and pulling up the cages, etc.

Interesting projects can be carried out in connection with coal. The children plan a self-help booklet called "The Story of Coal" in which they write down all the facts they learn or find out about coal, under these headings: (*a*) What coal is. (*b*) Where their own town or village gets its coal. (*c*) Where coal is found in Great Britain; list of coalfields. (*d*) The uses of coal; this means much thought and investigation. The children must think of all the valuable and useful things we get from coal—gas, coke, tar, dyes, benzole, etc. The Gas Company supplies an interesting little book telling about all the things that can be got from coal besides gas. (*e*) Substitutes for coal: *peat* in Ireland and parts of Scotland, *electricity* if it is made by water-power, *charcoal*. The children will find help in projects on coal, etc., in *Projects for the Junior School*, Book II, Chapter IV, "Wood Fires and Coal," Chapter IX, "Gaslight," and in Book IV, Chapter IV, "Keeping the House Warm" (Harrap).

(4) OTHER MINES AND QUARRIES, ETC.

The children find where there are iron mines and tin mines in the British Isles. They can add specimens of coal, iron ore, or iron-stone, tin, etc., to their museum. Quarrying for slate, stone, and other building material has been touched upon in the chapter on Home Geography, Chapter VI, and in connection with the first year's work, Homes and Shelters, Chapter VII. The children like to tell all they remember of these lessons. They can read for themselves about building materials and

quarrying for slate and stone, etc., in *Other People's Houses* (Harrap). There are good pictures in this book of slate quarries in Wales, limestone quarries, chalk quarries, etc. Salt as a food has probably been dealt with in the second year. The great salt district of Cheshire is a typical district. Much of the Cheshire salt goes north in canal boats along the Weaver Navigation Canal to the chemical factories of South Lancashire to make the chemicals needed in the cotton industry.

(5) MANUFACTURES: (*a*) CLOTHES

Talks about the busy towns where the things we wear are made revises, supplements, and completes the third year's work. Children can read for themselves and study selected passages from *What the World Wears* (Harrap). Boys and girls should in this year be able to read easily and write fairly well. They can now be asked to read more often from books, selected paragraphs, chapters, and sections for revision, to amplify a lesson given in class, and to write answers to easy questions. Thus a good deal more ground can be covered.

Time must also be given to making sure that the children know how to get the facts needed from each paragraph; that is, how to select information. Making their own geography books and self-help booklets is a help if the children never copy blindly from a book, but select.

First let the children find the *cotton towns* in South Lancashire and notice how well situated they are for the manufacturing of cotton goods. Cotton hosiery and lace are made in Nottingham and the surrounding districts. Next they cross the Pennines to find the principal *woollen towns* of the West Riding of Yorkshire. These two groups of towns are on or near coalfields. Woollen hosiery is made at Nottingham and Leicester. The children may also be told about the hand-woven, home-spun woollens of the Hebrides and the Shetlands, etc. The wool for the Yorkshire woollen towns comes from the sheep-lands of Canada, New Zealand, Australia, South Africa, and South America.

Boots, shoes, and leather goods are made in the Northampton district. Once the shoemakers of the district relied for the leather upon the hides of cattle raised in the Midland Plain, but now shoemakers depend on hides from abroad, Africa (Nigeria), etc.

Hats. The straw-hat industry is carried on at Dunstable, Luton, and other centres in the wheatlands of south-east England. But now this industry depends on straw imported from abroad. Why cannot England grow enough wheat to feed all the people and provide straw for hats? The felt-hat industry is carried on at Stockport and district. It is dependent on imported furs from abroad (especially Northern Canada). The cloth-hat industry is carried on in the woollen towns.

Silk—stockings, etc. Real silk is manufactured in Cheshire and Staffordshire at Macclesfield, Congleton, and Leek. The making of artificial silk and rayon has now become a great industry. Much of it is made in the "real silk" towns and in the cotton towns and also in places where no factories of the kind have been before; for example, at Braintree. Rayon is made from wood pulp at Coventry, Wolverhampton, Preston, and in North Essex and Flintshire.

Linen (collars, shirts, tablecloths, etc.) is manufactured at Belfast in Northern Ireland, and the Scottish linen towns.

(*b*) Industries to do with Food

This completes the second year's work and leads to thoughtful revision. *Jam-making*—the labels on the pots of jam will help children to find out where this industry is carried on. *Cocoa and chocolate*—Bristol (Fry's chocolate), Birmingham (Cadbury), etc. Why are these towns well placed for this industry? *Margarine*—on the banks of the Lower Thames, etc. The children trace the voyage of ground-nuts from West African ports to the Thames. Some margarine firms use palm-kernel oil from West Africa. These have such hard shells that they can be crushed only in special machines. One big margarine firm has a special palm-kernel crushing plant at Selby in Yorkshire. *Canned goods.* Children can learn much about canned goods by collecting labels. They may be able to visit a cannery. There are very big canneries at Ormskirk in Lancashire, at Sheffield, and in Cambridgeshire, Lincolnshire, and Norfolk. The canning of home-grown fruits and vegetables is a rapidly growing industry in Great Britain, hence the canneries in fruit-growing areas such as Cambridgeshire. *Biscuits*—Reading, Edinburgh, London, etc. *Sugar-beet factories* in Essex, and so on. Children will find industries connected with food in their own neighbourhood.

(*c*) Pottery (see Volume IV, Clay Modelling and Carving)

Children are often especially interested in pottery because of their history lessons and craftwork. The manufacture of all kinds of earthenware and chinaware is carried on in the North Staffordshire coalfield. So this district is called "The Potteries." There used to be a great deal of good clay in this part for pottery, and local clay is still used, but china clay or kaolin is brought from Cornwall (with the help of canals) to make the finest ware. Stoke-on-Trent is the centre of the "five" pottery towns. Let the children find Stoke, Hanley, Burslem, Tunstall.

(*d*) Iron and Steel

The most important occupations of all are: (1) the making of iron and steel; (2) the industries that depend on iron and steel, house-building (especially tall buildings), shipbuilding, bridges, machines and engines of all kinds, locomotives, railways, tramways, and hardware or metalwork of all kinds. Hundreds of things, from the biggest ship or bridge to very small things like nails or pins, are made of iron. Practically everything we use in our daily life is made with the help of iron and coal. Children are interested in making a list of things made of iron. It will be almost as long as their list of things made of rubber (Chapter IX). The great iron-manufacturing centres of Britain are: (1) the Black Country, where Birmingham, Wolverhampton, West Bromwich, Dudley, and Coventry are. These towns are on or near the South Staffordshire coalfields. (2) Another great iron district is in South Wales. Middlesbrough, a town on the Tees in North Yorkshire, and the district around smelt iron ore to produce iron and make many kinds of iron goods.

Other industries of interest and great importance are: *Motor-cars*, first built at Coventry, are now manufactured at

many centres. The Black Country has several important motor-car works, especially in and near Wolverhampton and Birmingham. At Dagenham, down the Essex side of the Thames, are the great Ford works; Greater London has a large output. South Lancashire, in the Manchester region, is another important producer of cars, and Cowley, near Oxford, can produce 50,000 a year. Boys will be interested (if they do not already know) in finding out what "makes" of cars come from these places—Derby, Bristol, Luton, Nottingham, *Huddersfield.*

Electrical engineering goes on in most towns and increases in importance since the power of the "grid" (the national network of supply) is used by more and more homes and businesses, etc. The biggest works of all are at Manchester. Other important centres are Coventry, Rugby, Preston, Birmingham, Loughborough, and the London area.

Cutlery and Tools. The most skilful makers of knives, fine tools, and delicate instruments are to be found in Sheffield and Rotherham in the Don Valley of Southern Yorkshire. Long ago local iron, coal, grindstones (made from the millstone grit of the Pennines, a hard, gritty rock), and water-power from the Don for turning the grindstone, made this valley a good place for making cutlery (knives of all kinds). The skilful workers or cutlers are still there today, but other things have changed. The iron is now brought from abroad, and electric or steam power does the work once done by the River Don. Propellers, engines, armour-plating for warships, fine steel goods, such as surgical instruments, scientific instruments, and tools for delicate work and high speed, are now made at Sheffield, which is famous all over the world for its clever workers.

The children will think of other industries to add to the above list, especially *local* industries, and other interesting industries such as paper-making, etc. How many of the above industries are stressed depends a good deal on the situation of the school.

It is important, however, that children should gain some definite knowledge of the positions and staple industries of the *principal towns* and of the occupations followed in different parts of the country. Through their study of the various industries, the children will realize how much we depend on other countries for our food and for the raw *materials* we need for our manufactures—cotton, wool, silk, straw, fur, leather, iron, etc. What can we give in exchange for all we need? Chiefly *manufactured goods,* motor-cars, parts of motor-cars, iron and steel goods from Sheffield, machinery, cement, etc. The people of the British Isles must therefore work hard and skilfully.

The children will realize how important our ships are, and our ship-building yards. They will be keen to find them on their atlas: (1) the Clyde estuary, one of the most famous ship-building districts in the world; (2) ship-building yards on the Tyne, Wear, and Tees; (3) at Belfast in Northern Ireland; (4) at Barrow-in-Furness in North Lancashire; (5) at Birkenhead opposite Liverpool on the Mersey.

The children will begin to understand something about *imports* and *exports.* All the goods brought into Britain must be paid for in some way. We have little or no food or raw material that we can export, so there

fore we must *make things* to sell abroad. Some money can also be made by carrying goods in ships for other countries. The story of the British Isles cannot be told without telling about the other countries on which these islands depend.

Let the children find the ports of the British Isles and the countries with which they trade. This makes a good revision lesson or lessons. First let the children find the *ferry ports.* All the railway systems have their special ferry ports where railway steamers and others start for Europe and for Ireland and the Isle of Man; for example, Harwich, Dover, Folkestone, Newhaven, Southampton (Fig. 73) are the ferry ports between England and Holland, Belgium, and France. The most interesting cross-Channel ferry-boats are those at Harwich. There one can see a whole train loaded with goods run straight down to the docks and pass on to the ferry (Fig. 74) which then steams out across the sea to Zeebrugge, in Belgium, where the train runs ashore with its load. In this way much unloading is avoided, and breakages of fragile goods are prevented. Many steamships take goods and passengers to Flushing and the Hook of Holland, whence they can go by train right across Europe and Asia, even as far as China Then the children can find the great ports for liners that go to all ports of the world—London, Liverpool, Manchester, Glasgow, Bristol, Belfast, Hull, Southampton, Cardiff, etc. The children find what goods are brought to each port (imports), and what goods are carried away to distant lands. Tracing the voyages of some of the ships helps to remind the children of the position of the British Isles. Some children like to make booklets about

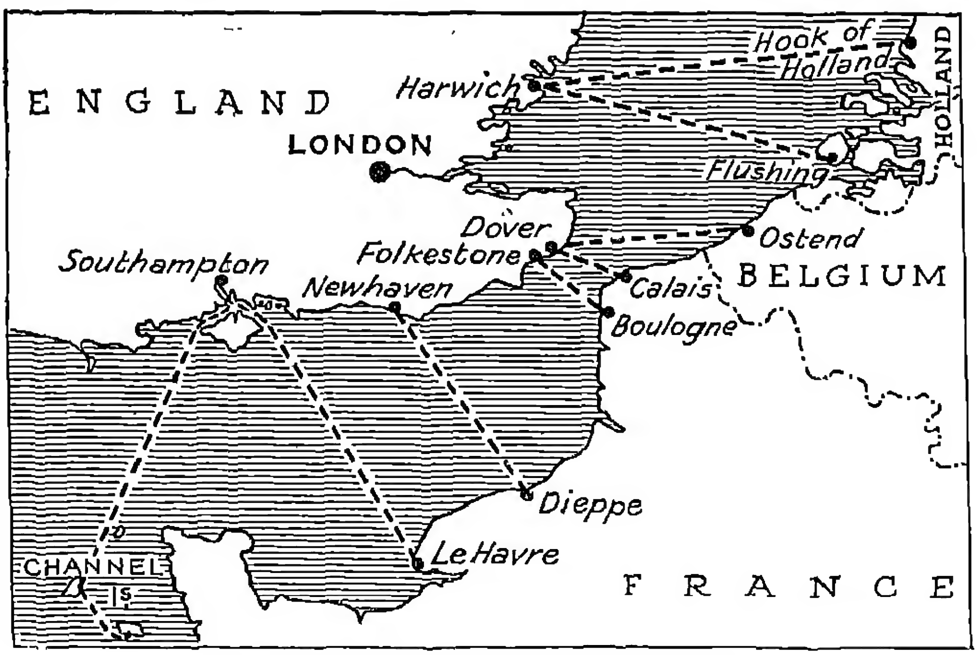


Fig. 73.—The Ferry Ports of South-east England.

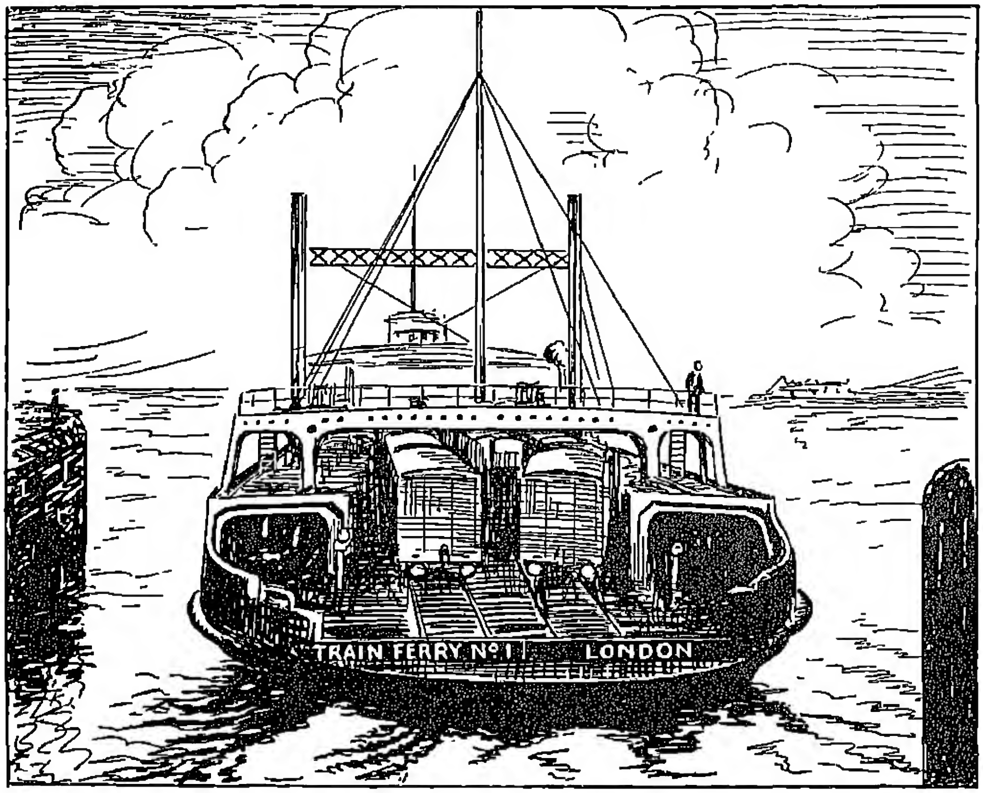


Fig. 74.—A Harwich–Zeebrugge Train Ferry

"Imports and Exports." In their booklets they arrange the ports in some order, for example—ports on the west coast—and add a few notes about the exports and imports of each, thus:

> Liverpool: *imports*—grain (wheat, maize, barley, oats), raw sugar, raw cotton, petrol, fruit, meat; *exports*—iron and steel goods, sodas and salt, cotton goods, machinery.

They fill up their books by degrees. They may be able to find more imports for Liverpool, or more exports.

There are several projects in connection with industries that the children may suggest; for example, they can collect all the "Wheels of Industry"—the great wheels at the top of the pit-head of a coalmine, the wheels in cotton and woollen factories and power stations, where electricity is generated, etc. But best of all children like collecting the wheels of industry found in the home and garden—sewing machines, carpet sweepers, lawn mowers, garden rollers, etc.

Many children like making booklets about Iron, corresponding to their booklet about Coal. In *Other People's Houses* they can find out how iron and steel are used in house-building. They will like to have some pages for "The Use

of Iron in the Home," and see what a long list of useful things made of iron they can compile.

It is not always easy to find suitable books for children to read for themselves. They are not interested in too detailed a description of how iron is obtained from iron-stone (iron ore), or how boots and shoes are made, yet one wants to interest them in industries. They may like to read "How the Engine Works" in *English of Your Daily Life*, Book IV (Longmans). This is useful for combining English and general knowledge. Of course reading about "How Things are Made" is not strictly geography, but an interest that arises from geography. A book that appeals to many intelligent children is *Shaping and Making: a Picture-book of Crafts* (O.U.P.). This is a picture-book with brief text describing very simply the work of twenty different craftsmen, including a potter, a tinsmith, a glass-maker, a rope-maker, and a basket-maker.

The children can also read about brick-making, quarrying (granite, limestone, sandstone, chalk, slate), making cement (Britain exports cement) and concrete, iron-mining and iron-smelting, the making of steel, and the use of iron, tin, and lead in house-building in *Other People's Houses*. This links their last year's work with their first year's work. They can read about clothes in *What the World Wears* (Harrap).

Again, the children should be encouraged to consult books in the Free Library, where they may find some "treasures." Encyclopædias also contain good pictures and notes. The success of one's teaching and one's syllabus is evident when the things learnt become part of the child's daily thoughts as it were, that is, part of his interests.

PENDIX

/oyages of Famous Explorers

: voyages of Columbus, Vasco da , Cabot, Humphrey Gilbert, ;h, and the Pilgrim Fathers are with in Volume II. They belong, ' notes in Volume II show, to the of History. The story of Colum- ; of special importance, and the ; to be brought out and errors to voided are given in detail in ne II. The reasons for the im- nce of the voyages of the other rers are also stressed.

: first voyages *round the world*— of (*a*) Magellan's ship, the *Vit-* and (*b*) Sir Francis Drake—are taken in the geography lesson in :ction with lessons on the globe, 'oyages east and west (see Chapters ıd IV). Some imaginary voyages been taken in Chapter II to help children to understand the real ing of east and west, but it is also to take the voyages of real e. Some teachers use the story ıese voyages to teach the winds. ships of long ago were at the y of the winds. The danger of g stories of voyages is that too ı time is spent on details and chil- have merely confused memories of :sting stories. The best plan is to ; the points the children are to mber in lesson periods and try to .hem to read the details of the ;es for themselves, as suggested olume II.

eresting stories of great explorers ɔe found in the "Men of Courage" Series, by L. Edna Walter (Newnes Educational Publishing Co. Ltd.). The explorers dealt with are: Book I—David Livingstone; Book II—Captain Cook; Book III—Marco Polo; Book IV—Ferdinand Magellan; Book V—William Dampier; Book VI—John Franklin.

The most useful stories of exploration from the point of view of geography are those to do with Australia. These stories make a fitting introduction and the best approach to the physical characteristics of this continent. But as the detailed study of Australia belongs to the Secondary School stage, they do not concern us here. In the Secondary School, North America, South America, Asia, etc., may be approached, if desired, by way of stories of explorers.

Although the main content of the curriculum of the Primary School has been written in terms of subjects, it has been pointed out again and again how these subjects cannot be kept in watertight compartments. Teaching by subjects in the Primary School is rather different from teaching by subjects in the Secondary School. Even in the Secondary Schools teaching by subjects tends to stifle thought. No one can think properly in terms of one subject, and both teacher and pupils may be hindered by specialization. Often one finds real light thrown on some historical material in what is ostensibly a geography book, and vice versa.

The coming section on Arithmetic shows how much arithmetic can mean

to children through its association with other subjects—Geography, History, Art, Handwork, etc. It ceases to be mechanical and becomes something of interest that enlivens the work of the school.

It is to keep alive the natural interrelation of subjects that the project method is favoured by thoughtful teachers. But even the project method can become mechanical if it is used for the purpose of spectacular exhibitions and not to encourage thought.

Lessons are true to the project spirit when they inspire a child to write as a ten-year-old boy once wrote about his Bible lessons: "The Bible stories are stories about everything we learn—Nature Study because it tells stories about stars and flowers; Geography because it tells about shepherds and their sheep, harvesting and threshing corn, finding honey to sweeten food, crossing deserts, and many other things; History because there are stories about people who really lived long ago; Literature because some of the stories are lovely and there are songs; Arithmetic because it tells you about the weights and measures and arithmetic used long ago. Then, of course, Scripture, as it tells how men tried to be good and serve God." This was an answer to a question given at the end of the term on "Name some Bible stories that you like, and tell what you learnt from them."

An artificial project might drag into a Scripture lesson all these subjects, but the project method of teaching makes the child himself see how much of one subject there is in another. Certainly the link between Geography and History, and Geography and Scripture, is most helpful (see Volume II).

The teacher in the Junior School needs, in a sense, far more knowledge than the teacher in a Secondary School, or perhaps one should say, less rigid knowledge. The day, one hopes, has long gone by when the work of a teacher in a Primary School was considered easier or less important than the work in a Secondary School.

Geography and History Pictures for Group Work and Individual Work

National museums, art galleries, etc., are able to supply pictures, views, and postcards that are useful both for the geography and history lessons. Descriptive price lists may be obtained by writing to the Director, Curator, or Secretary of the institution in question:

The British Museum. The Director, British Museum, London, W.C.1. Very valuable pictures for teaching Ancient History.

The British Museum (Natural History). The Director, British Museum (Natural History), Cromwell Road, London, S.W.7. Useful pictures of animals, birds, etc., useful for the nature-study and geography lessons.

The Victoria and Albert Museum. The Director, Victoria and Albert Museum, South Kensington, London, S.W.7. Pictures of ships through the ages. Textiles, Spinning and Weaving, Costumes, etc. Useful pictures for both geography and history lessons.

The National Museum of Wales. The Director, National Museum of Wales, Cardiff.

THE IMPERIAL INSTITUTE. The Director, Imperial Institute, South Kensington, London, S.W.7. Very useful postcards and illustrated leaflets about all places that are part of the Empire or British Commonwealth of Nations.

THE ROYAL BOTANIC GARDENS. The Curator, Royal Botanic Gardens, Kew, Surrey. Postcards, etc., useful for nature study and geography.

THE HORNIMAN MUSEUM AND LIBRARY. Forest Hill, S.E.23. Very useful ideas can be obtained for lessons on "Travel and Transport by Land and Water," "The Evolution of the Domestic Arts," "Agriculture, Preparation of Food, Fire-making," "Basketry, Pottery, Spinning and Weaving," etc.—and so on. Much of the material helps both with projects and handwork.

THE TEACHING OF ARITHMETIC

CHAPTER ONE

WHY TEACH ARITHMETIC?

THINKING casually, one categorically exclaims, What can be easier than the teaching of arithmetic! Where can there be a difficulty in it! Children learn numbers almost as automatically as they learn to eat. Teachers have solely to instruct in the manipulation of those numbers in four or five processes. In addition —well, anyone can add numbers. And anyone can as easily un-add them. To multiply numbers and to unmultiply them, one has to know tables, and they can be attained parrot fashion. What can be simpler?

That is casual thinking.

But thinking more deeply, one arrives at the exactly antipodal conclusion. The teaching of arithmetic is a very profound matter, an immeasurably vexed question. Arithmetic cannot be taught by the unskilled, any more than can art or music or elocution. It is not the Cinderella subject of the curriculum. For the past two centuries men have been studiously concerned in the scientific teaching of arithmetic. Yet still how varied are the expressions of their opinions! And how much at variance are those varied opinions! As opposite as the poles! So opposite that they appear to present a problem as difficult as the time-honoured irresistible force meeting the immovable object!

What say some modern people interested in arithmetic teaching, people interested not theoretically but very practically?

The business-man storms, "Why send me boys who know no more of arithmetic than that they add 2 and 3 and make them 6! In my day we *did* arithmetic. We didn't play at it, we did it. For heaven's sake, let's have more and more of it in the schools today!"

The irate mother calls on the head teacher with the complaint, "Mary was tossing about all night talking in her sleep of 7 times 5 and 9 times 4. The child is being pushed too much. You are turning her into a nervous wreck, so the doctor says!"

One child says—a verbatim report— "I like playing with numbers, but I don't like arithmetic. I don't see any sense in it."

The officers of a Local Education Authority say—again a verbatim report—"The time-tables in our schools are overbalanced by the excessive time allowed for arithmetic."

The teacher of arithmetic in the

Secondary Grammar School says, "These children from the Primary Schools come to us without a sufficient basis of arithmetic. It is most essential that the syllabus there is extended at once."

The teacher in the Primary School visits the head teacher and emphatically declares, "I cannot possibly get through the arithmetic syllabus. It is full time it were curtailed. Here is one term almost gone, and I'm at Exercise 14 only. I ought this week to be doing at least Exercise 25. I must have more time. Can I squeeze out geography this afternoon?"

Those are the cries. "More arithmetic," "less arithmetic," "easier arithmetic," "less time for arithmetic," "a wider arithmetic syllabus," "a narrower syllabus or more time for it." Assuredly a very vexed question is the teaching of arithmetic!

I repeat, "How much at variance are those varied opinions!"

Can those opinions be reconciled?

Let us leave the answer to that most important question to a later stage, and in the meantime ask the simpler, fundamental one of "Why teach arithmetic at all?" Why worry about it, when any unanimity concerning its teaching seems to be impossible? Why not cut it out, once and for all, from the school curriculum?

Arithmetic has been taught in Asia for at least 2,000 years. In most countries the purpose was utilitarian. In China, in India, and in Mohammedan lands, education centred in a study of the sacred books. Arithmetic was quite incidental, and received the meagre attention called for to furnish sufficient knowledge for the then small business of life.

As inter-town, inter-tribal, and inter-racial trade grew, a greater numerical knowledge became necessary. More time was spent in the teaching of arithmetic in Babylonia, in Assyria, and in Jewry. It is interesting to note that among the inscribed finds of ruined Babylon banking accounts are frequent, dating as far back as the time of Darius.

Rome, to govern satisfactorily its vast empire, found larger numerical calculations a necessity.

The later commercial linkage of the cities of Northern Italy with the East introduced arithmetic into Mid-Europe. From them it passed to the Hanseatic towns, whence it spread fanwise to other trade centres.

In all the countries named, always was number work taught for purposes of trade. Always was there the utilitarian aspect, and none other.

In the case of Greece there was a difference. The Greeks taught number work under two names: *logistic* and *arithmetic*. Logistic was the term given to what we today think of as arithmetic, that is, the rules of numerical calculation and their practice. It was taught solely for utilitarian reasons, that the student of it might enter efficiently the world of commerce. Arithmetic to the Greeks was the study of the properties of numbers, tending to what we now know as Higher Mathematics. It had little to do with the concrete. It had no concern with mechanical calculation. It was not intended to have, for its study was to produce good philosophers, men of logic, of developed minds, men with a liberal education. Neither logistic nor arithmetic was universally taught. To the majority of the Greeks both logistic and arithmetic were unknown. Logis-

tic was for the future trader, and arithmetic for the leaders of thought.

We still teach the logistic and the arithmetic of the Greeks, and we name them both arithmetic. For what reasons do we teach them? Why teach arithmetic at all?

There appear to be at least four good reasons.

Arithmetic has an Ethical Value

That teacher's magic "R" placed on a finished calculation gives to a child immense satisfaction. He watches eagerly the course of the red pencil. Will it shape the desired "R" or the objectionable "X"? When the "R" appears he knows he has attained. He has reached absolute correctness. There can be no doubt about it. For number work allows of no personal tutorial opinion. In every other subject the teacher's likes and bias can vastly affect marks. An American student's English examination paper was marked quite independently by a number of examiners. None knew any other's marks. Several of the examiners failed the student, many placed him among the average, quite a number gave him a credit, and a few awarded him a distinction. And all the assessment of the one student's one answer paper! How absurd! Such could not be, had the paper been on arithmetic. The subject does not offer a range of personal interpretations of the answer. Sums are either "R" or "X." Thus the child can with certainty reach perfection. Perfection! Glorious achievement! Which other school subject *always* offers it? Who can create a standard of perfection for the testing of every answer in English, in geography, in religious knowledge? For a statement of perfection in art, to whom shall we turn? To Holbein or Epstein, to Constable or Picasso? Who has set a standard of perfection in music? Has Beethoven or Mayerl, has Sir Walford Davies or Duke Ellington? But arithmetic offers absolute, unassailable perfection. Surely the striving for, and the possibility of reaching, that which cannot be bettered is character-training which cannot be excelled.

Arithmetic has a Utilitarian Value

In this present-day commercial world the average citizen must know how to manipulate numbers. He must have that knowledge when he shops, when he travels, when he receives change at the cinema, at the dog-racing track, at the sports meeting, when he banks his savings, when he checks gas or electricity consumption, when he finds the wave-length on his radio receiver, when he pays income tax, when he buys by the hire-purchase system, when he—does a thousand and one other things. Men and women today must have more than a smattering of arithmetic. It is a daily necessity both within and without the home. Life in a modern civilized country and a knowledge of number calculation are almost synonymous terms.

Arithmetic has a Cultural Value

Consider what happens when a child has a sum to do. The child reads the sum. The statements contained in it he has to comprehend, following which he has to analyse them to discover points of connection between parts of them. He has then by logical steps to reach the answer. Let us take, for example, this sum: "In a hall are 30 rows of chairs with 18 chairs in a row,

and 2 shorter rows of 16 chairs each. If at a concert *6d.* a chair is charged, and every chair is occupied, how much money is taken?" In the reading of the sum the child recognizes that it deals with chairs and a charge for them. On analysing the terms of the sum he finds the charge depends on the number of chairs. His logical thinking leads him to multiply 30 by 18 and 16 by 2 and to add the products. He argues that as the charge for one chair is *6d.*, the total charge will be x times *6d.* The powers of comprehension, of analysis, of logical thinking are doubtless used, maybe unconsciously, but none the less they are used. And they are powers of no mean order. Their development is necessary for a successful participation in this world of complex situations. More than ever before, the average man has to sum up possibilities of action, and to decide on the best course to pursue. Shall he expend his earnings on this or on that? Shall he answer the newspaper advertisement and move his home to another place for employment there? What effect will such change have on his children's health and their education? For whom shall he vote at an election? How will the country fare if a certain party's ideology is the ruling factor? Yes, a trained mind is very essential even in the lowest walks of life. Arithmetic helps in the production of that cultured mind. By the doing of the "daily dozen" there is invaluable mental training. "Arithmetic is like a whetstone, and by its study one learns to think distinctly, consecutively, and carefully." [1]

[1] Hutsch, *Arithmetic portensis*, 1748. Quoted by D. E. Smith in *Teaching Elementary Mathematics* (Macmillan).

Arithmetic has a Personal Value

Arithmetic has also a personal value, for children like it. Most of them will tell you that "doing numbers" is a pleasant lesson. It is unfortunate that the name "arithmetic" has a bad odour. "A rose by any other name would smell as sweet," but arithmetic by another name would smell sweeter. Arithmetic in schools fifty years ago was a subject of drudgery. How could it be otherwise? Was not the head teacher paid by results? Did not his living depend entirely on the number of sums got right at the annual inspection? Were his pupils not drowned in vast seas of unintelligible figures? Men and women of that school-generation talked and still talk of their abhorrence of what was taught as arithmetic. The subject has much to live down, but it will succeed in doing so, by reason of the common sense of its modern presentation. Numbers appeal to children.

Children appreciate design. They love making patterns with bricks, beads, marbles, pastels, wool. They appreciate numbers, for in number is design, and balance, and plan (Fig. 1).

Children appreciate rhythm. They cannot analyse a melody, but they naturally love the rhythm of a band, just as the negro is appealed to by jazz and the uncultivated musical mind by "swing." They love, too, the undulating flow of the nursery rhyme, of the jingle, of the poem. Rhythm is in their blood. They appreciate numbers, for in number is rhythm (Fig. 2).

Children appreciate the majesty that is in numbers. The little fellow of three who stood in front of the grandfather clock threw out his chest as he said, "Dad, it's eighty past minutes to nine." The numbers meant nothing to him,

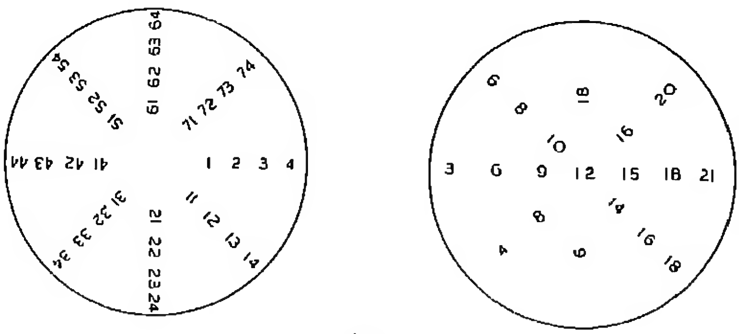


Fig. 1.

but they sounded big and grand. Numbers are grown-up things. Is there not something majestic in the statement, "The *Queen Elizabeth,* of 89,000 tons"? Is not the statement that "A pilot reports that he has seen geese flying at a height of 30,000 feet" of vaster significance than "A pilot reports that he has seen geese flying at a tremendous height"? Yes, children appreciate the majesty of numbers. They boast in them. Have you heard them?

Children are fascinated by numbers. How many of their early songs contain them: "Ten little niggers," "One, two, buckle my shoe," "Baa, baa, Black Sheep," and so on. Children of a wide age-range are often seen with their note-book and pencil entirely engrossed in the occupation of collecting motor-car and railway-engine numbers. Recently, on a school educational visit by road to a museum, the children of ten years of age were invited to note on signposts the numbers of the roads traversed. Enthusiastically they all fell in with the idea, children of the "B" class as much as those of the "A" class. It was great fun. It was a game of numbers.

Teach Arithmetic?

Of course. There can be no doubt about the answer. Arithmetic has unmeasured value as a school subject. It is ethical. It is utilitarian. It is cultural. Above all, it is liked by the children who have to do it, when it is presented to them as a living subject.

Fig. 2.

CHAPTER TWO

THE HISTORY OF ARITHMETIC

HAVING decided conclusively that arithmetic must retain a place in the school curriculum, the next step is to determine the progression of instruction in the subject, the course on which the teaching shall proceed. Shall the choice of that course be haphazard? Shall there be a babel of tongues plotting it? Shall it be left to individual ingenuity and personal preference? Or is there a pointer directing with any definiteness a logical sequence of steps along which to go? Is it possible scientifically to map the course?

It has been said that the individual is an epitome of the race, that in him is the race crystallized. If that be so, then the individual develops in the manner of the racial development. There certainly seems to be an analogy in the process of articulation. The baby gurgles. He grows and utters monosyllabic sounds. The child becomes noun conscious He then enunciates concrete ideas. Later, at some point in his life, he thinks and then speaks in the abstract. From prehistoric to modern man that, too, has been the progression of vocal transmission of thought.

The theory, then, is that the individual is the history of the race in miniature. From that theory we should be able to obtain our wanted teaching sequence. As arithmetic has developed through the period of human existence, so ought its unfolding to be to an individual. Historically should be the presentation of arithmetic to the child. But there will be, of course, a great difference. The race sought for long centuries for a method of numeration. The child has no need to do that searching. The child need not grope as did his forbears. The groping has been done. The race has arrived at the method, and it is now in our possession. It is our business to pass on that possession. And as James Ward says in the *Educational Review*, "We are trying to manufacture a mathematician, not to grow one."

A consideration of the historical growth of number knowledge and the evolution of calculation processes must therefore be of immense value to the teacher of arithmetic. His scheme of work can be safely determined by the racial growth of the subject. But he will not follow that growth meticulously. He will lop off all twisted and gnarled and knotted branches, and leave only that which will bear him abundant fruit.

In the few pages allotted in this book, a very meagre outline only of the history can be recorded. For fuller information teachers should read W. W. Rouse Ball's *Short Account of the History of Mathematics* (Macmillan, 1901), *The Psychology and Teaching of Arithmetic*, by Harry Grove Wheat (Heath, 1937), *A History of Elementary Mathematics*, by Cajori (Macmillan),

or *The Story of Arithmetic*, by Cunnington (Allen & Unwin). An excellent presentation for children is *Number Stories of Long Ago*, by David Eugene Smith (Ginn).

The Initial Step

Have you noticed how many indefinite quantitative words or phrases are in common and constant use in our language? There come to the mind at once those bugbears of the teacher of English, "lot" and "lots." How frequently are they written and spoken! For what a multitude of expressions do they do duty! On looking through a recent issue of a newspaper I found all of the following: shorter, highest, longer, many more, greater, less than, big, abundant, a large number, for some time, younger, plentiful, a long period, most people. Is it that we as a nation are satisfied with vagueness and looseness in our mode of speaking and writing? Do we use these words and phrases because we are too lazy to be more exact? I think not. There is another reason, I feel sure.

Early man knew nothing of number. He was not able to count. Such an accomplishment to him was quite unnecessary. His possessions and those of his friends were so few. He might at times have to inform the other members of his small tribe of an approaching *large number* of enemy animals. Quite likely he would indicate the number by some appropriate gesture, as a modern fisherman tells his more-or-less credulous listeners of the immensity of his miraculous catch. On the other hand, the savage man might use some sound indicative of *herd*.

We can imagine him sending his young sons to find *many* or *lots* of sticks for his fire or flints to be made into his scrapers, awls, chisels, arrow-heads, and other tools and weapons.

A needle made from the long bone of a swan was one of the treasures unearthed, years ago, from the Glacial-period Hohlefels cave in Swabia. The needle had an eye. Did the prehistoric maker's wife, when she tried to thread it with her reindeer skin thong, point out to him that it had to be *larger*? Did she also suggest to him that the necklace of perforated animal teeth he had made for her would not go round her neck, and therefore it must be *longer*?

There is no doubt that our terms *pack* and *herd* and *flock* originated in words used by man when he recognized groups rather than individuals or exact numbers of individuals.

In those first days of division of labour, when one man made arrow-heads, another obtained food, another made pots, they bartered their productions. The swopping took place in the manner of what Margaret Punnett calls "One-one correlation" (*The Groundwork of Arithmetic*, Margaret Punnett, Longmans, 1941). The arrow-heads and pots were placed side by side in pairs, and were thus counted without the use of numbers. It is reasonable to suppose that exchange was often held up because the arrow-heads were found to be *less than* or *more than* the pots.

In our imaginings I think we have man's first acquaintance with quantity. Very indefinite he certainly was, but more exactness was unnecessary for his mode of life.

The Second Step: Counting

Very early man learned to recognize individuals, units, ones, and he learned,

too, to record those ones. Among the finds in the Post-Glacial remains in the Schussen Valley, Germany, was a branch of a reindeer's antlers. Into it were filed notches. Some of them were about one-twelfth of an inch in depth. Some were finer ones joining two others much deeper. Oscar Fraas, the great geologian, says those notches are definitely numerical signs, probably calling to memory the killing of reindeer or of bears. And they were made when? Geologists reckon that the Post-Glacial period was some 100,000 years ago. Evidently man kept "tallies" then. It is a far cry from this prehistoric period to the days of King John of England, yet the officers of the national exchequer were still keeping "tallies" in A.D. 1200.

Savage man discovered that he carried about with him a most convenient tallying apparatus, namely, his hand and fingers. He did not as yet count on them. He marked off by means of his fingers. He was still using the "one-one correlation."

An extension of this "one-one correlation," and an advance, were made when man compared quantity in groups of objects. Apparently he used some very common thing as his standard. James Gow, in *A Short History of Greek Mathematics* (Cambridge University Press, 1884), tells us that: "'Two' is in Thibet *paksha*, '*wing*'; in Hottentot *t'Koam*, 'hand.' So again with the Abipones, 'four' is *geyenknate*, 'ostrich-toes'; 'five' is *neenhalek*, 'a hide spotted with five colours.'"

From the ability to talk in indefinite quantities and to keep "tallies," man passed to the greater ability to count. Certainly his counting was very limited. The extent of it was *one, two, many*. Any number of things more than two was beyond his power of numerical recognition.

He probably found very little difficulty in recognizing "one." Was he not himself one, his wife one, his cave one, the thing he was making one, his bow one, and so on? First he became aware of the individual object, and then the abstract idea of the number of it. That is an important point we ought always to remember. Numbers are not concrete. The world did not give man numbers, as it gave him trees, and rivers, and flowers, and mountains. Number is a conception of man's mind, a conception born of much labour. I humbly disagree with John Stuart Mill when, in his *System of Logic*, he says, "All numbers must be numbers of something; there are no such things as numbers in the abstract."

The number "two" also gave man little trouble. In his "one-one correlation" he worked in pairs. There was "this" and "that," and the answer became "two."

It must have been a long time before the idea of "three" was conceived. The very name is most significant. The dictionary informs us that "three" is derived from the Latin *tres*. But *tres* has an origin in the Sanskrit *tri*, meaning to cross, to go beyond. Man in mentally conceiving "three" went beyond the border, he crossed the beyond. What an achievement! That, to us very simple abstract realization, was a tremendous step forward towards modern mathematics.

Many primitive tribes in Australia and South America still have no greater numbers than 2, 3, and 4.

Primitive man in due course found

that he carried with him not only a natural tallying apparatus but also a natural number machine, namely, his hand and fingers. We must not forget that tallying and counting are entirely different operations. If the judges at a boxing match make strokes to represent points scored by a boxer, they do not know the total of their tally until they have counted the strokes marked down. They tally first and count afterwards.

Fingers increased man's counting ability to *five*. With this increase he found it possible to number to 29. He said, "One, two, three, four, five, five and one, five and two, five and three, five and four, five and five, two fives and one," and so on to "five fives and four." After that the objects counted were still "many."

When man discovered that he could use his two hands and their fingers, counting to ten became possible, and ten different names—in some cases the names of the fingers pointed to—took the place of five. Using numbers to ten, man was able, by the same system that he used to count to 29, to enumerate to 109. He ended thus: "Ten tens and nine."

Some tribes in Africa employ the ingenious method of using two pairs of hands. On the fingers of one man, 10 are counted. The "ten" is then transferred to a finger of the second man. One of the calculators in this way acts as the "units" man, the other as the "tens" man. The two men can thus count 100 articles, although they recognize them as "ten-tens," and the counting is double-checked. (A promising method for classes of small children, where conversion from units to tens is in progress!)

In tropical countries, naked feet suggested the practicability of counting to 20, both fingers and toes being utilized. Here the basis of numeration becomes 20, in the manner in which we count in scores and talk of an age of three score years and ten, and the French speak of *quatre-vingt*.

Some people counted in 12's; among them were the Babylonians and Assyrians. Again we can compare our own use of 12 = a dozen, 12 inches = 1 foot, 12 pence = 1 shilling, and in the old measure 12 ounces = 1 pound. Others counted in 4's, some in 7's, and others in 11's.

But the general base of notation, the seemingly natural one, has become 10. E. A. Greening Lamborn, in his fascinating and provocative *Reason in Arithmetic* (Oxford: Clarendon Press, 1930), speaks interestingly on this point. "The decimal scale . . . has become universal, because, unfortunately, men were made with ten fingers. I say 'unfortunately' because twelve or even eight would have been a far more convenient number for reckoning purposes. . . . The critics of our old-fashioned weights and measures do not always realize that their bases of 12, 16, 112, and so on, are not fortuitous nor the blunders of barbaric ignorance. They were chosen deliberately to avoid reckoning in tens. For the only convenient way of dividing ten is in halves; and as quarters, and even half-quarters and thirds and twelfths, are sometimes required, ten is a far less satisfactory base than twelve or sixteen."

There are three points to note in connection with the naming of numbers.

First, "one," "two," and "three"

appear to be of a different type from all the others. Why did the Romans decline their "unus," "duo," and "tres," and not their "quattuor," "quinque," and so on? And why is the declination of these numbers similar to that of the adjective "bonus"? Was it that the Romans considered "one," "two," and "three" to be descriptive words? If the names of the other numbers were *nouns*, why were they not placed in one of the declensions of the nouns? Maybe the names were handed down from other languages where they had not the significance of single words, but of phrases. The word for "four" in the tongue of the Zuni Indians is *awite*, and that signifies "all the fingers all but done with" (Wheat's *Psychology and Teaching of Arithmetic*).

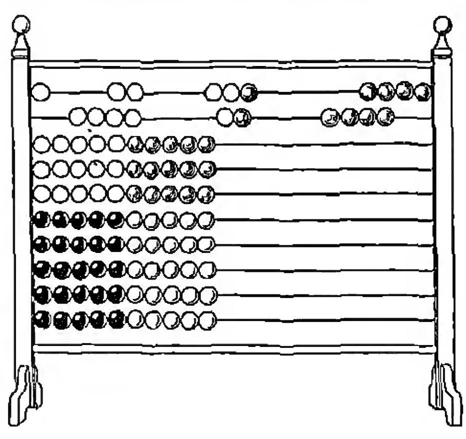
The second noticeable point is that man named to ten and then with faultless design used the names to ten to construct names for the greater numbers. This planned number-naming was another advance in systematized arithmetic. (The exceptions to the plan in our own language are "eleven" and "twelve." "Eleven" is derived from the Anglo-Saxon *endleofon*, which may mean *en*=one, and *lafan*=leave, i.e. the one left after ten, and "twelve" from the Anglo-Saxon *twelf* and Gothic *twalif*, which meant possibly "the two left."

The third point to note is the importance of the actual names. Man could now count his sheep. He recognized them individually as one, two, three, and so on. But he also had them now in order—first, second, third, and so on. That is to say, not only did he now count the individuals of what had been to him merely a "flock," but he added order and sequence to his counting. He could now say that his Number Four or his Fourth sheep needed attention: it was lame. This order in counting constituted another advance.

When man thought that if he could count to 109 he should also be capable of counting to higher numbers, and when he found that his hands and fingers were insufficient for that greater counting, he commenced to invent artificial number machines.

His earliest effort was a wooden table, on the surface of which he scratched a series of grooves. Alternatively, he covered a smooth table with sand, and made the grooves with his fingers. In the first groove were placed pebbles, or other small movable objects, to be counted as units. In the second groove the objects were moved as tens, in the third as hundreds, and so on.

This developed into a bead frame or abacus. It was used in slightly differing forms in all parts of the world when and where there were civilized peoples. We find it employed by the Etruscans and the Aztecs, the Greeks and the Chinese, the Hindus and the Russians, the Egyptians and the Japanese.



The Romans developed the abacus, adding to it two wires, one holding four beads to represent fractions whose denominators were four, and the other with twelve beads for fractions with a denominator of twelve.

The use of the abacus proves that man had learned to count not only in units, but also in groups. For nine counts he moved forward nine beads on his first wire, but for the tenth number he moved back those nine beads and put forward one on his second wire. That bead represented ten, a group of ten, ten units but only one ten. It was the same size as the beads on the first wire, and it still represented one, but with the difference that it was one group of ten. I have laboured that point because of its importance. Man had come to recognize position value.

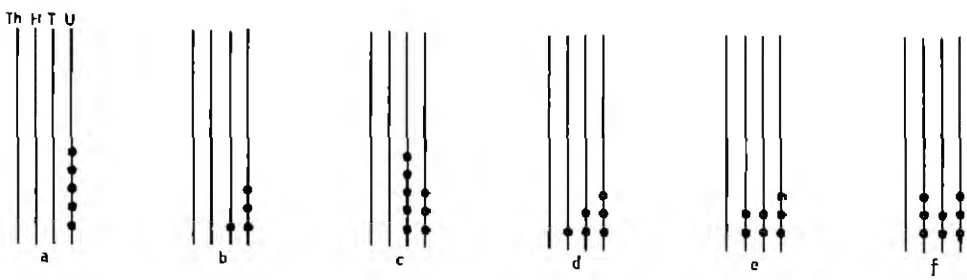
The Africans referred to earlier in this chapter had also realized this place value, when they counted by the use of four hands, two for the units and two for the tens. There was also realization of place value when man used heaps of pebbles for counting. As his sheep passed him he placed pebbles together. For each ten on one heap he put one on a second heap, the tens heap. For each ten on the second heap he put one on the third heap, the hundreds heap. His chief trouble, I should imagine, would be to remember which heap was which. Using beads of differing colours, instead of pebbles, probably solved his difficulty. But the abacus with its fixed wires demanded no strain on the memory. Units, tens, and hundreds "heaps" were immovably fixed in position.

On the abacus, calculations to very large numbers were possible. It could be and was used for the processes of the four rules of addition, subtraction, multiplication, and division. In carrying through these processes man worked on the fundamental facts that subtraction is un-addition, multiplication is continued addition, and division is continued subtraction.

The following are examples of the abacus being used for the four rules.

Addition

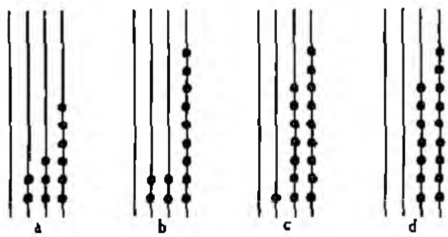
Let us suppose we wish to add 145 and 178. These are the steps taken, using lines as the Romans did, and pebbles.



The 5 units of 145 are first counted (*a*). Then the 8 of 178 is added (*b*), making 1 ten 3 units. Next, 4 tens of 145 are counted (*c*). Added to these is the 7 of 178 (*d*), making 1 hundred 2 tens. Then the hundred of 145 is added (*e*), and lastly the 1 hundred of 178 (*f*). The answer, it will be seen, is 323.

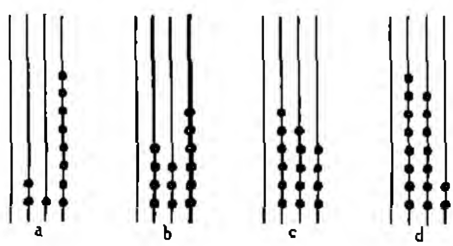
SUBTRACTION

Let us use the example 236 minus 157.



The abacus is set at 236 (*a*). To take 7 units from 6, one of the tens must be converted into 10 units, and the remainder will be (*b*). Next, to take 5 tens from 2 tens, a hundred has to be changed into 10 tens, and the remainder will be (*c*). Lastly, the 1 hundred of 157 is subtracted, and the answer is 79 (*d*).

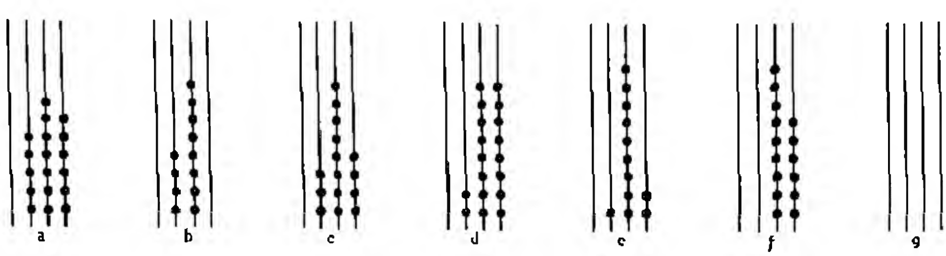
MULTIPLICATION: the process of continued addition. Example: 218 x 4.



218 is counted on the abacus once (*a*). Then 218 is added (*b*). Added again for 3 times, it becomes (*c*). The fourth addition makes (*d*) the answer, namely, 872. Of course, each addition of the number requires all the steps of the normal addition.

DIVISION: the process of continued subtraction. Let us divide 576 by 96. 576 is counted on the abacus (*a*). 96 is subtracted once (*b*), a second time (*c*), a third time (*d*), a fourth time (*e*), a fifth time (*f*), a sixth time (g), and nothing remains. The answer obviously is 6. Again, each step is a complete subtraction, and the whole division sum is undoubtedly a lengthy business. Many opportunities there are for slips to be made in the counting, and users of the abacus considered division to be by far the most difficult of their calculations.

Although this advance through the centuries in the recognition and counting of greater and greater numbers was striking, although man thought in groups as well as in units, although he realized place values, in reality little progress in numerical thinking was made. It was mainly mechanical and concrete. Merchants for centuries used their fingers for counting, and, by an evolved symbolism (in a way, similar to that used by the deaf and dumb), for representing numbers. When buying and selling, they appeared to be gesticulating wildly. The abacus was in daily use to a very late date. All old



arithmetic books contained instruction in its use. Even in an edition as late as 1610 Robert Record (the inventor of the sign =) described to his readers how to calculate by it.

The great step forward was when there dawned upon some brilliant mind the fact that the number 10 represented not only a group of concrete things, but also an abstract idea. When the discovery took place and whose was the intellect are outside our ken. The man must have been a scientific genius, a Pythagoras, a Galileo, a Newton, a Lodge, but his is a name

"Unsung, unhonour'd, unremembered"

The Third Step: Numerals

Somewhen, man, having learned to speak his thoughts, conceived the idea of writing them. Among his writing he recorded numbers. In early Egyption hieroglyphics the symbols used for the numbers one, two, three, were one, two, and three fingers. (For Egyptian numerals from 1 to 1,000 see Volume II, HISTORY.) Later the fingers were narrowed to straight lines. For quite a period this straight-line system of representation was in use. In a Greek inscription of the year 398 B.C., ετεος (IIIIIII) signifies "the seventh year."

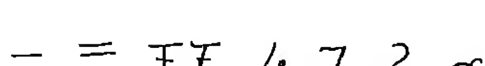
It must have been a tedious method. You, being a Phœnician, wished to express the number 187. Straightway you wrote 187 strokes. No wonder you, or another Phœnician, or an Egyptian, introduced a separate symbol for 10 and another for 100. Your recording of 187 then became 7 strokes, 8 times the symbol for 10, and the symbol for 100. Very much shorter certainly!

The Romans shortened the writing again by introducing symbols for 5, 50, and 500. For their symbols they used V for 5 (possibly the shape of the space between outstretched thumb and first finger), X for 10 (maybe a double V), L for 50 (half the symbol early used for 100, which was [ ), C for 100 (*centum* = 100), D for 500 (half the symbol early used for 1,000, which was ↀ), and M for 1,000 (*mille* = 1,000). The Romans would have written 187 thus: CLXXXVII.

The Babylonian and Assyrian systems of numerals are shown in Volume II, HISTORY.

The Greeks used a system known as the Alexandrian. Their symbols were the letters of their alphabet, α for 1, β for 2, γ for 3, and so on. 1 to 9 were thus the first nine letters of the alphabet, the tens 10 to 90 the next nine, the hundreds 100 to 900 another nine. As their alphabet consisted of twenty-four letters only, they had to import another three. (Older Greek numerals are pictured in Volume II, HISTORY.)

Progress in the use of numerals was made simultaneously in many parts of the world. While Mediterranean races were increasing the total of their figure symbols, another system was being developed in North India. In the second century A.D. separate symbols for figures were constructed from the initial letters of the Indo-Bactrian alphabet. Zero only was missing. That was invented at a much later date. These were some of the forms used:

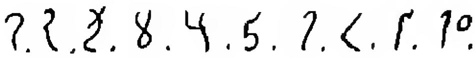


1 2 4 6 7 9 10

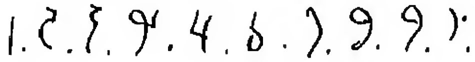
The following were evolved from them (according to Isaac Taylor's

Alphabet, London, 1883, and Leslie's *Philosophy of Arithmetic*):

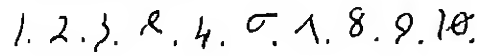
Indian numbers, *circa* 950



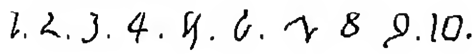
Arabic, *circa* 1100



German, 1385



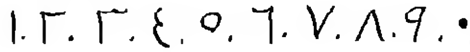
Caxton, 1480



These steps demonstrate the production of what are termed our "Arabic" numerals. They are really Indian, brought to us by the Arabs. We should prefer to call them "Hindu-Arabic." It is highly probable that Leonardo of Pisa, who lived about A.D. 1150, and who wrote a book, *Liber Abaci,* introduced these numerals into the commercial life of Mid-Europe.

There is a most interesting brass of one, Thomas Fortey, Northleach. The year 1447 on it is inscribed in mixed symbols, in this way: MCCCC  The thousand and the four hundreds are in Roman numerals, the forty and the seven in the symbols of the German numerals of 1385 (see previous column).

The Arabs who traded with the Middle East developed their number symbols thus:



Very ingenious is the suggestion that our numerals were obtained from squares (Fig. 3).

Certainly the suggestion is clever, but it is also highly improbable, I feel. The Hindu-Arabic derivation is too convincing to admit of another.

The Fourth Step: Processes

The natural result of knowing how to count and of acquiring a numerical system was to invent processes of calculation. As we have seen, the abacus was in use for these processes. Addition and subtraction could be done quite simply, but multiplication was too lengthy to do more than to multiply by small numbers. As to division, it was thought to be a process to be carried out only by the most expert users of the abacus.

It became necessary to conceive other means of multiplying and dividing.

Multiplication tables were constructed, but they were not extensively used.

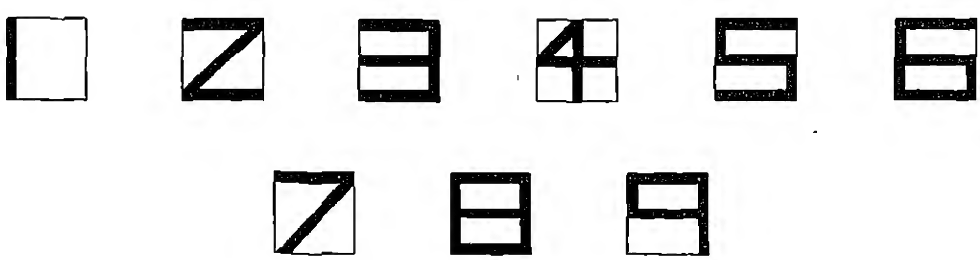
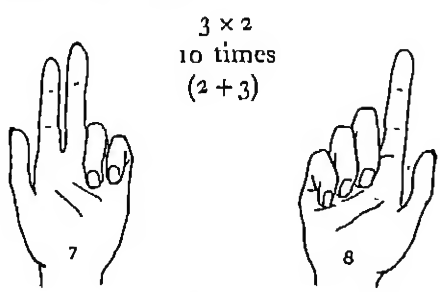


Fig. 3.

A quite clever means of multiplication, employing those two natural number machines, the hands, was in use. It assumed a knowledge of tables up to five times five, and that simplest of all tables, the ten times. One hand represented the multiplicand, the other the multiplier. A hand with open fingers and thumb symbolized 5, one finger closed 6, two fingers closed 7, and so on. The answer to the required multiplication was the product of the number of fingers (and thumb) open in one hand and the number open in the other, added to ten times the total number of fingers closed in both hands. Try it! It works!



$10(2 + 3) + 3 \times 2 = 56$, which is the answer to 7×8

A book published in London in 1686, entitled *Travels of Sir John Chardin in Persia*, described the use of rods for the purpose of multiplication. Previously John Napier had introduced them, in an improved form, into England, and he described their use in his book *Rabdologia*, published in the year of his death, 1617.

The rods of the Persians were of suitable material, such as bone and wood, and on them were engraved the multiplication tables, with the tens figures higher than the units. This is what they looked like (Fig. 4).

Suppose 3,826 is to be multiplied by 9. The rods 3, 8, 2, and 6 are taken out. Along the ninth row on these four rods are found two lines of figures. If they are written and added in this way

```
2715
 7284
34434
```

the correct answer is obtained. If the multiplier is of more than one figure, the process is repeated for each figure, and the answers of the several additions are themselves added, care being taken to get right place values.

To work a division sum by the method used by the Near-East mathematicians one would proceed in the following manner:

Suppose 65,382 is to be divided by 429. Columns are drawn, one for each figure of the dividend. This is placed at the head of the columns and the divisor is written near the bottom, room being left for the answer. (See

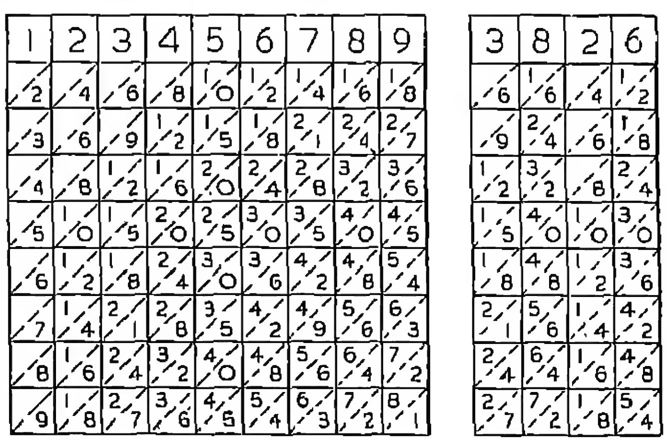


Fig 4

Fig. 5.) The first figure of the divisor is put in the same column as the first figure of the dividend.

Dividing, 4 goes into 6 once; 1 is placed under the last figure of the divisor, and a division sum is worked as shown. From the steps of the first division the remainder is 22,482. The divisor is placed one column to the right, and division again takes place; 4 into 22 goes 5, 5 is placed in the answer, and a second short division is done. The process is repeated after moving the divisor again one place to the right. The answer is 152, and there is a remainder of 174.

A very tedious method, but a worthy ancestor of our present way of dividing.

6	5	3	8	2
4	0	0	0	0
2	5	3	8	2
	2	0	0	0
2	3	3	8	2
		9	0	0
2	2	4	8	2
2	0	0	0	0
	2	4	8	2
	1	0		
	1	4	8	2
		4	5	
	1	0	3	2
		8		
		2	3	2
			4	
		1	9	2
			1	8
		1	7	4
		4	2	9
	4	2	9	
4	2	9		
		1	5	2

Fig. 5.

The Italians favoured a process known as the "scratch" method, because after a figure had been used it was scratched out. This is how it would be used to do the division sum just done by the Persian method.

2
22
234
65,382(1
429

429, placed under the 653 of 65,382, goes once. $1 \times 4 = 4$, and 4 from 6 leaves 2. Put the 2 above the 6. Cross out the 4 and 6. $1 \times 2 = 2$. 2 from 25 leaves 23. Put down 23, 2 above the previous 2 and 3 above the 5. Cross out all figures now used. $1 \times 9 = 9$. 9 from 233 leaves 224. Put down 224, 2 above the other 2, 2 above the 3, and 4 above the 3 in 65,382. The next number to be divided into will be 2,248. So the first steps in the working will appear thus:

		2
	2	~~2~~2
2	~~2~~3	~~2~~~~3~~4
~~6~~5382 (1	~~6~~~~5~~382 (1	~~6~~~~5~~~~3~~82 (1
~~4~~29	~~4~~~~2~~9	~~4~~~~2~~~~9~~

For the next step, the divisor will be set down in this way:

2
~~2~~2
~~2~~~~3~~4
~~6~~~~5~~~~3~~82 (1
~~4~~~~2~~~~9~~9
42

The process is repeated for the second and third divisions.

This surely is more tedious even than the Persian method. But how grateful must we be to the "ancients" who directed us in the way!

One or two other points of development need to be outlined.

The signs + and − occur in Widman's *Arithmetic* of 1489, but they were first laid stress upon, as symbols to show what process to use, by Stifel in 1554. Robert Record introduced the sign = in 1557.

Fractions have been in use for many centuries. The Greeks and Egyptians simplified all fractions to sums of fractions with 1 as numerator. For example:

$$\tfrac{3}{4}=\tfrac{1}{2}+\tfrac{1}{4}$$

therefore $\tfrac{3}{4}\times\tfrac{1}{7}=\tfrac{1}{2}\times\tfrac{1}{7}+\tfrac{1}{4}\times\tfrac{1}{7}=\tfrac{1}{14}+\tfrac{1}{28}$

The Romans worked with a constant denominator of 12, and the Babylonians with one of 60.

As to decimal fractions, they were written as $38,2'5''6'''$ or $38_0\ 2_1\ 5_2\ 6_3$ when first used. Early in the seventeenth century Briggs suggested that the form should be changed to $38,\underline{256}$ and later this became 38|256. Our present method 38·256 dates from the eighteenth century.

So has been the course of the development of the counting, of the writing, of the processes of calculation of number. If our initial premise that "the individual is the epitome of the race" is true, then our progressive steps in the teaching of arithmetic are determined for us. The children must be taught to count, to write numbers, to make calculations with them. But further questions immediately arise. When? At what age? When will they be capable of comprehending new steps and new rules? How far shall our syllabus go? Can we go beyond a point understandable by them? Shall we teach them only that which they will use in after-school life?

Those queries and many others must be decided by us as teachers.

CHAPTER THREE

SATISFYING ARITHMETICAL DEMANDS

IN this chapter I would like to consider again the opinions on number knowledge given in the first chapter, and to associate with them the history of the development of arithmetic outlined in Chapter II. There is a link between them.

The question was asked, "Can the very conflicting demands for arithmetical knowledge and the varying opinions on the teaching of arithmetic be reconciled?" Can we satisfy the business-man and the Secondary Grammar School teacher who want more arithmetic, the parent who wants less strain put on her child, the child who wants number work and not arithmetic, the officers of the Local Education Authority who think that too much time is allocated to the subject, and the Primary School teacher who wants more time or less syllabus with which to cope?

I am of the opinion that *the demands of the Secondary Grammar School teacher cannot be met. The others can be.*

The business-man deplores his youthful employee's incapacity to calculate. He is quite right. The majority of modern children do not calculate accurately. Gone are the days of grinding arithmetic, of long tots, and of vast numerical manipulations. And with them, apparently, has disappeared, too, the power of doing accurately mechanical operations. The pendulum has swung from the entirely Greek "logistic" to the Greek "arithmetic." That swing was progressive, but has it gone too far? Are we concerned too much with mental training and too little with mechanical practice? F. A. Hill, in *Educational Review, IX*, says: "While accuracy and speed in simple fundamental processes have been underestimated, the value of presenting numerous and varied themes in pure arithmetic, and of pressing each to great and difficult lengths, has been overrated." The employer rages for more arithmetic. He doesn't really mean that. He is not asking for a wider scope, an extended syllabus, an inclusion of a greater field of mathematics. No, not more arithmetic, but a truer knowledge of that already taught. The employer can assuredly be satisfied by us. There must be a balance in our teaching: the child, as well as being able to discover what type of process he must use, must also be able to complete the process with exactness.

The parent objects to pressure being put on her child. She has reason on her side. Pressure should not be needed. If an arithmetic course is carefully schemed, and if each year's progression is conscientiously done, the child of normal intelligence need find

no stress in the subject. The crux of the matter is thoughtful planning (planning in accord with the historical arithmetical development of the race), and the thorough treatment of each and every step in the planning. Other planning will either teach the child no arithmetic, or give it and its teacher both headache and heartache. I am sure we need worry neither mother nor child.

Is it necessary for the child to think of arithmetic as being separate from number work? Where does number work end and arithmetic begin? I suppose the Infant School time-table designates the lesson "Number Work," and the Junior School, being more grown-up, alters the subject title to "Arithmetic" or "Mathematics." Does the change bring disfavour to the child mind? Why should it? I have heard of children in an Infant School clapping their hands when, for a punishment, they were told to do number work. Would the children of some Class IV's act similarly, or would they snort with disgust and consider themselves excessively punished? In 1941 Messrs. Cassell & Co. published some junior arithmetics which I had written. The sums in them were chosen as much as possible from children's experience, that is, they were not far-fetched, isolated arithmetic, but were an extension of the child's own leisure-time number play. And the result? A teacher of a Standard II has reported to me that never before in her long years of school work have the children of her class done what they do now. If she gives them an opportunity towards the close of an afternoon to do anything they like, the majority take out their arithmetical text-books and do sums. I would like to know what those children consider they are doing, "number work" or "arithmetic"? Whichever it is, they do it!

Can we satisfy both the Local Education Authority officers and the teacher in the Primary School? My personal opinion is that we can, if, in the Primary School, the Authority's officers recognize a minimum allotment of fifty minutes a day for arithmetic. Less than that is not sufficient, but if the work of previous classes has been thoroughly done, a reasonable syllabus can be worked through in any class in a year on a fifty-minutes-a-day basis.

The Primary School teacher says that the present syllabus is *not* reasonable. Because of preparation for the Secondary Grammar School Entrance Examination, the teacher points out, too much is required. The answer to that is in the hands of the examiners setting the questions. But it is not the case in all counties; for example, in the county in which is situated my school, no problem or mechanical test in arithmetic is set which demands more than intelligence and a sensible knowledge from the candidates. It is to be hoped that in the near future no external requirements shall be allowed to interfere anywhere with a rational scheme, planned entirely in accordance with the capacity of the child.

The Secondary Grammar School teacher must not ask for more. There is a definite limit to the child's capabilities. When one considers how many centuries it has taken to arrive at today's knowledge of arithmetic and arithmetical methods, one has to challenge too great a demand on the developing "epitome of the race." Like race, like child. A long, long period is

required for simple counting, for number writing, for place-value recognition, for the acquisition of simple process calculations. If these, as the groundwork of arithmetic, have been taught thoroughly in the Primary School, the Secondary Grammar School teacher need have no fear. He will be able to build both speedily and accurately.

Now, how can we end the clamours raised concerning arithmetic teaching? How can we guarantee satisfaction to the voices making those clamours? Several factors of great importance will have to be considered before such a guarantee can be offered.

Of First Importance is the Teacher

He (and "he," of course, throughout this book includes "she") must be in love with his subject. This is as necessary as in the case of the teacher of art, of music, of history, of the so-called "more pleasurable" subjects of the curriculum. His love must result in a close study of the art of teaching the subject, for it requires a technique as much as does any other teaching subject. In the past it has been the practice in the Primary School for all members of a staff to teach arithmetic, for all were thought to be capable of teaching it. Because every teacher could add, subtract, multiply, and divide every teacher was expected to take arithmetic. Everyone did not teach art or music, because everyone was not musical or artistic. But every teacher knew his tables and could count, therefore he was adjudged fit to teach arithmetic. His capabilities did not, however, ensure success, for with the knowledge there might be no love of the subject. Of many a teacher was this true, and to many the teaching was distasteful drudgery. How could children be inspired by such leading? Is it a wonder that some have said they do not like arithmetic? The teacher of nature study, in love with nature, can raise unbounded enthusiasm in children for the subject. So, too, can the teacher of arithmetic. To be a success he must arouse interest, curiosity, and a desire for inquiry, and he must create the exhilarating quickening of the spirit of adventure. That he cannot possibly do if the subject bores him himself. To him, arithmetic must be a daily adventure into the vast realms of numbers, and his class will go with him with the delight of explorers into the unknown. Such are the teachers we need: teachers who are enthusiastic arithmeticians, who will shout with their class, "Hurrah! it's time for arithmetic!"

On which subjects of the week do you spend most time in preparation—those you do not like or those you do? Those lessons that are a bore to you, how do you prepare them? Hurriedly—for you haven't patience to think about them? Yes, I thought so. I am a teacher, too! Do you teach arithmetic, and do you dislike it? When you prepare it, do you write in your Note or Record Book "Lesson 'X' from the text-book" for the following week's work? And do you sigh with relief and mentally say, "That's that!" Much arithmetic preparation has been done in that way, I am sure, for results prove it. A careful planning is as essential to arithmetic as to every other subject.

I have stressed the point that the teacher of arithmetic must have a passion for it. His passion must be passed on and enthuse his pupils. On

no account must his scholars be allowed to work grudgingly. He must arouse their interest, for interest is the great motive power, and interest will develop into the love that is so essential. The standard of the teacher's preparation will determine the standard of the children's interest. In his preparation, the teacher should remember that children possess five senses, and of these the sense of sight, the sense of hearing, and the tactual sense are the three most vital to his teaching. A week's work should be prepared with the background knowledge that these senses are at his command. Let us illustrate concretely. Is the teacher preparing for the introduction to the measure of capacity? His wrong method, his sure way of defeating himself, will be to state the table and straightway to set sums in the four rules. His right attack will be to get a bucket of water, a cup, a milk-jug, a jam-jar, a milk-bottle, a hot-water jug or jugs, a watering-can, and a set of measuring beakers. It is always great fun to children to play with water. Add to this the interest of finding how much the various vessels hold comparatively and exactly, and the week's work will start with a great urge. When later the more sober written work is done, the class will do it with understanding. Pints, quarts, gallons will be real things. The children's tactual and sight senses will have been brought into play to the advantage of their mental working.

Yes, says the teacher, that is very easy in that one case. But often such an approach is impracticable. That is not so. Are you teaching division of money? Let the children divide into groups actual or cardboard coins. Let them see the impossibility of dividing a pound note into (say) seven parts. Let them see the necessity for changing the note into shillings. Is your subject the table of weights? Borrow a coal-sack, a coalman's weight ticket, a $\frac{1}{2}$-cwt. weight. Let the children compare the weight with that of a lb. Take the children out to see the coalman and his lorry when he delivers coal and coke to the school. It will not be waste of time even to take your class to the railway goods yard to see the carts being weighed as they leave the station. And so with all lessons, ingenuity and thought—that careful preparation which is so essential—will always produce ways and means.

Especially in the teaching of arithmetic must the educator get down to the level of the immature mind. That is extremely difficult. It is really astonishing how many little matters bother the child. It is to be borne in mind that we are not dealing with such as Zerah Colburn, the mathematical genius of Vermont. When he was eight he was asked the question, "What are the factors of 4,294,967,297?" Within twenty seconds, by mere mind operation, he answered correctly 641 and 6,700,417. In contrast, the little minds we are trying to develop do not readily realize such simple facts as that the space between two long strokes on a ruler is an inch, and the two strokes themselves do not make two inches. They frequently err when they multiply by 0, for zero needs a deal of understanding, being a "place" and not an integer. I wonder if we puzzle them when we tell them that 5×4 is the same as 4×5. We ought to be most accurate in our statements, for we are teaching an exact science. 5×4 is *not* the same as 4×5. The result of the

product may be the same, but in one we have 4 groups of 5 in a group, and in the other 5 groups of 4 in a group. (Which is which? Even mathematical minds are not decided as to the correct answer.) Even the writing of farthings as $\frac{1}{4}d.$, $\frac{1}{2}d.$, $\frac{3}{4}d.$, creates difficulty, and has to receive far more than casual attention. Rousseau in his *Emile* suggests that "were it possible he (the teacher) should become a child himself." He also says, "The apparent ease with which children learn is their ruin. You fail to see that this facility proves that they are not learning. Their shining, polished brain reflects, as in a mirror, the things you show them, but nothing sinks in. The child remembers the words, and the ideas are reflected back.

"Although memory and reason are wholly different faculties, the one does not really develop apart from the other. Before the age of reason the child receives images, not ideas; and there is this difference between them: images are merely the pictures of external objects, while ideas are notions about those objects determined by relations.

"I maintain that as children are incapable of judging, they have no true memory. They retain sounds, form, sensation, but rarely ideas, and still more rarely relations. You tell me they acquire some rudiments of geometry, and you think you prove your case; not so, it is mine you prove. You show that far from being able to reason themselves, children are unable to retain the reasoning of others; for if you follow the method of these little geometricians, you will see they only retain the exact impression of the figure and the terms of the demonstration. They cannot meet the slightest new objection; if the figure is reversed, they can do nothing. All their knowledge is on the sensation-level, nothing has penetrated to their understanding." Those are very sweeping statements, but there is much truth in them.

Rousseau has stated the main difficulties. The child of tender years has little reasoning, much imagery, few abstract ideas, and less association of ideas. To get into the child mind, the teacher must "become a child" by thinking in "images," making "images" the focus of his preparation, and speaking in the language of "imagery." Films appeal to children because they are in the language of the youthful mind. They are pictures easily picked up by the eye and readily photographed on the receptive "polished brain." The cinema is the teacher's rival. He should learn from it its technique, and as the child in the audience begins to reason as to what will be the result of a series of actions portrayed on the screen, so will he gather ideas and begin to reason from the imagery of the teacher.

The questions put by the child in the arithmetic lesson are an excellent index to his mind. None should be passed over. Rather should they be encouraged. In fact, the teacher will be far on the road to success if he can get his pupils to talk arithmetic. In no better way can he find and work at their level. Such a conversation as the following, with, say, a Standard IV boy whose powers of reasoning are developing, would prove invaluable:

"Please, sir, is $\frac{1}{8} \times 16$ really a multiplication sum?"

"Certainly it is, Tom."

"I think it is dividing."

"Why?"

"Well, when you multiply you expect the answer to be greater, and the answer here is less."

"What is the answer, Tom?"

"I make it 2, and 2 is much less than 16."

"I see, but another way of looking at it is that 2 is much greater than $\frac{1}{8}$."

"That may be so, but surely the answer to a multiplication sum should be greater than the number you multiply and the number you multiply by."

"You are perfectly correct if both the numbers are whole ones. But when one is a fraction, the answer will not be greater than both numbers. You see, if I write the sum $\frac{1}{8} \times 16$ as $\frac{1}{8}$ times 16, I want 16 only $\frac{1}{8}$ times. Really I want 16 put down not 3 times, or 4 times, but only $\frac{1}{8}$ times."

"Yes, I think I understand that, sir, but I think still it is a division sum. You are dividing 16 into 8 parts, and taking only one of the parts."

"So you would prefer the sum to be set down as $\frac{16}{8}$?"

"Yes, that is better."

"And you will be finding $\frac{1}{8}$ of 16 or $\frac{1}{8} \times 16$ when you work that sum."

It is highly probable that Tom at this stage would not be convinced. That does not matter. What does matter is that he does not take for granted all that is told him, that he is beginning to wonder for himself, that he has commenced to think and to reason arithmetically, and that he has confidence that the teacher will help him.

Lastly, it is exceedingly important that the teacher shall have clearly in mind the object of the teaching of arithmetic. Bacon, in his *Advancement of Learning*, says: "In the mathematics I can find no deficience, except it be that men do not sufficiently understand the excellent use of the pure mathematics, in that they do remedy and cure many defects in the wit and faculties intellectual. For if the wit be too dull, they sharpen it; if too wandering they fix it; if too inherent in the sense they abstract it. So that as tennis is a game of no use in itself, but of great use in respect it maketh a quick eye and a body ready to put itself into all postures; so in the mathematics, that use which is collateral and intervenient is no less worthy than that which is principal and intended."

The *Handbook of Suggestions for Teachers* issued by the then Board of Education (1937) states that "the teaching of mathematics in the Elementary School has three main purposes: first, to help the child to form clear ideas about certain relations of number, time, and space; secondly, to make the more useful of these ideas firm and precise in his mind through practice in the appropriate calculations; and thirdly, to enable him to apply the resulting mechanical skill intelligently, speedily, and accurately in the solution of everyday problems."

Those three purposes constitute the aim of teaching arithmetic for its utilitarian value. The statement does not include the second important aim. As I have said before, the subject has a definite culture value. Bacon felt that, those centuries ago, when arithmetic was taught almost solely for its usefulness in commerce, when he wrote, "Pure mathematics remedy and cure many defects in the wit and faculties intellectual." Children should be led to think logically Pure logic is beyond their comprehension. The logic of arithmetic is not. Therefore the teacher should bear in mind the fact that the

objects of his teaching are two, the utilitarian and the cultural, the one to enable him to solve everyday problems, and the other to help him to reason logically concerning any situation in which he finds himself.

Which is the more important of these two aims it is impossible to say. As easy to answer is the question, "Which is it more important to do, to eat or to drink?" Sufficient is it to realize that both aims must have due consideration, that planning for the development of the reasoning faculty must not preclude practice in mechanical accuracy, neither must numerical manipulation supersede entirely the problematic.

To sum up this first factor of such importance, the teacher must be in love with his subject, he must prepare it efficiently, he must think at the child's level, and he must have constantly before him the aims of his teaching.

The second important factor is the time allotted to the subject. If the subject be considered as a utility only, if all we have to do is to produce machine-like calculators, then arithmetic is allowed more time in the week than is necessary. But, on the other hand, if the cultural value is to be considered, a much greater proportion of the children's time must be taken up by the subject.

Although, early in this chapter, I suggested fifty minutes as a minimum daily teaching time, no one at present is able indisputably to say how much time should be allocated to the subject. Thorough statistical investigation needs to be done before a final decision can be made. It is not true that unlimited increased time spent by children on any subject has the effect of unlimited output. That is as true of adults as of children. It was found to be the case in munition factories during the recent global war. There is a definite optimum time beyond which the law of diminishing returns operates. That time limit, I repeat, is at present unknown.

A *Research Bulletin* published by the Board of Education, Detroit, in 1926, records the following. Owing to restricted accommodation, a class attended a school on half-days only. Naturally subject times, including those of arithmetic, were reduced. It was found that the arithmetic of this half-time class almost equalled that of similar children attending full time. Before a conclusion is arrived at concerning that result, one would like to know the test that was given. So much depends on that test.

The Australian Council for Educational Research investigated the matter also. It found the average time set apart for arithmetic in a large number of schools. Then it tested the performance of sets of children in all grades in two types of school. In the first, far more than the average time was allotted to arithmetic, in the second type far less. There was a difference in the two types ranging around 150 minutes per week. The result of the test showed in most grades a higher standard in the first type than in the second In the tests in addition, subtraction, and multiplication, however, children in the age-groups 10–11, 11–12, 12–13, spending less time on arithmetic, excelled those spending the greater time. They had concentrated more on the purely mechanical, for the answers to problems set were markedly of a lower attainment in these groups of the less-time schools than in the others. That bears out my first contention, that

greater time is necessary if arithmetic is to be treated as a cultural subject, and its full value offered to the children.

There is a second problem relative to the number of minutes allotted during the week to arithmetic. How shall those minutes be used? Here again no definite answer can be given. Discussion with practising teachers of arithmetic only demonstrates the extent of disagreement amongst them. The *Handbook of Suggestions for Teachers* gives no clue. The writings of all the authors it has been my pleasure to study contain no authoritative statement. The lessons may be spent (*a*) in memorizing tables, (*b*) in practical work, (*c*) in oral work, (*d*) in "mental" work, i.e. in the writing of answers mentally found to set simple sums, (*e*) in mechanical calculations, and (*f*) in working out problems. Shall one only of these divisions constitute each lesson? Shall there be daily "mental" work? A long series of similar questions can be asked. Of course, no single answer for the whole range of school years is possible. What would be advantageous to one age-group would be disastrous to another. Suggestions only can be made, for at present there is no authority to say so many minutes for this, and so many for that.

In the Infant School the work will be almost entirely of a practical nature. I feel that from the under-sevens no written work should be demanded If an Infant feels an urge to put pencil to paper, I would not deter him, but I would not ask him to do so. In the lower standards of the Primary School there will be the memorizing of tables, much practical and oral work, mechanical calculations, and to a small degree problem work. As one goes through the age-groups of the Primary School the memorizing of tables will become unnecessary, "mental" work will be introduced, practical and oral work will continue, and there will be more and more time spent on the working out of sums set in the problem form. Until thorough scientific inquiries are conducted, such a rough outline is the sole one possible to be made.

Summing up this second of the factors of successful arithmetic, one has to say that no exact quantitative statement can be made as to the minutes which ought to be allotted to the subject, nor how those minutes should be split up. What can be said is that there should be balance to effect the aims for which arithmetic is taught, the aim of utility and the aim of culture. The teacher will plan most carefully to maintain that balance if he has the same ideas as had Lady Mary Wortley Montagu. She, in 1753, wrote to her daughter concerning her grandchild, "I am particularly pleased to hear she is a good arithmetician; it is the best proof of understanding: the knowledge of numbers is one of the chief distinctions between us and brutes."

The third important factor is the syllabus of work. One of the most pleasing features of the English educational system is the freedom given the head teacher and staff in the conduct of the school. That allows of initiative and experiment which are essential if in the school there is to be liveliness of effort. It allows of a choice of material fitting a school's special needs and environmental conditions. Of course, freedom does not mean licence. Common sense presupposes an extent of uniformity and a basic amount of work

to be done. Beyond that, freedom means an unbound outlook.

The *Handbook* of the "Board" of Education does not outline the Primary School arithmetic syllabus, but refers the reader to its Educational Pamphlet, No. 101, *Senior School Mathematics* (published in 1937). This pamphlet states:

"The parts of the syllabus which may fairly be expected to be permanently known by all normal pupils are:

"(1) Addition and subtraction of whole numbers, money, lengths, times, weights and capacities without undue complexity as regards numbers and units.

"(2) Short and long multiplication and division of numbers.

"(3) The process of reduction applied to simple examples only.

"(4) Short multiplication and division of money, lengths, times, weights and capacities.

"(5) Addition, subtraction, multiplication and division of fractions with small denominators.

"(6) Mensuration of rectangles and cuboids.

"It is to be understood that applications will be numerous and well-varied in type, and will be introduced as soon as sufficient knowledge of numbers is available.

"Surprise may be felt at the omission from the foregoing list of long multiplication and division of money, weights, etc., and at the inclusion of so much work on fractions. Experience seems to show in regard to the former that so much mechanical practice is needed to attain proficiency that it would not be reasonable to expect all pupils to have mastered these processes fully by the age of 11 years. Work with simple fractions, on the other hand, is easier and enlarges powers in obvious ways; it is not essential that the rules of H.C.F. and L.C.M. should have been formally taught before such work is undertaken."

That, I feel, is a reasonable syllabus, the "reasonable syllabus" demanded by the Primary School teacher of our first chapter. But my freedom permits me to state some points of disagreement with it. I *would* include in the Primary School long multiplication and division of money, weights, etc. My experience is that the majority of the under-twelves *can* do with success these somewhat lengthy calculations. I would also include the teaching of simple decimals. Why not? They are, after all, but another form of fraction.

With a large amount of work in vulgar fractions I unhesitatingly disagree. Some work with simple ones, yes, by all means, but the understanding of the multiplication and division of fractions by fractions needs developed reasoning powers. Truly, the pupils will learn readily to use the rules, and "invert the dividing fraction and multiply," but will they comprehend what they are doing? They must do, if the work is to be of any value.

I write as if in the background there were no haunting shadow of Secondary Grammar School Entrance Examinations. This pamphlet agrees with me, for it states that it is most important that "examiners should be familiar with the syllabuses and aims of the Junior Schools and that the examination questions should be based on the work specified in" the syllabus it has outlined.

It also agrees to an extent with my

disagreement of it, for it continues its basic syllabus thus:

"Among the topics which will usually be *broached* [the italics are mine] in the Junior School and in which considerable progress will be made by the abler pupils, but to which further attention in the Senior School will have to be given, are the following:

"(i) The applications of rules already learnt to less simple numbers and to a wider range of problems.

"(ii) The introduction of long multiplication and division of money, lengths, times, weights and capacities

"(iii) The use of alternative methods such as Simple Practice.

"(iv) The decimal notation with addition and subtraction; the meaning of percentage.

"(v) Simple practical geometry and drawing to scale."

I still have to disagree. I would not waste time teaching Simple or any other kind of Practice, and I would not *broach* these subjects. They should be a part of the basic syllabus.

There is no need to sum up this third factor. It is already a summary.

Our offer of satisfaction, then, is comprised of these three factors—the teacher, the time allotted to him, and the syllabus on which he works. A thoughtful teacher using with care all the minutes of his arithmetic periods, and from his syllabus preparing assiduously the day's, the week's, the month's, the term's work, will satisfy even the most devastating of our critics.

CHAPTER FOUR

THE SCHEME OF WORK

SAVAGE man passed from thinking in indefinite quantities to the counting of individuals. He then learned to group the individuals. On becoming civilized he performed numerical calculations practically. Then he invented symbols to represent his numbers, and with them he speeded up the time taken on his calculations.

The child entering the Infant School at the age of five will have had some experience of quantity. It is reasonably certain that he will be capable of using with understanding such terms as longer, shorter, taller, bigger, heavier, many, few, lots. Probably he will have some knowledge of counting, for he will have numbered the stairs as he ran up and down them, listened to his sister as she counted her skipping steps, noted the number of buttons on his coat, become aware of the number of friends he had at his birthday tea-party, and so on. The extent of his experience will have depended very largely on the interest of his parents, on the type of his companions, on his general home environment. But however much or little he knows, it is the business of the Infant School to teach him to count, to recognize sequence in numbers, to perform practically very simple number processes, to acquaint him with numerals, and the relative value of those numerals. Learning to count must come first. That is historically sound. The counting will not be satisfactory as a parrot-fashion repetition of 1, 2, 3, etc. The numbers will have to be related to objects. Then will come the question of which to teach first, figures or processes.

Pestalozzi, the revolutionary Swiss arithmetic teacher of the school at Yverdon from 1805 to 1825, contended that no figures should be taught until a child could count to ten, and until he could prove his comprehension of those numbers by doing simple processes with them. Maybe the modern teacher will prefer the children to have experience in processes before teaching figures, maybe she will introduce them at the same time processes are being performed. In either case there will not be the time lag there was in the progress of racial knowledge. How much faster would arithmetical development have been had the early civilized man produced his figure symbols as soon as, or soon after, he used numbers for his mechanical operations!

With that work in the Infant School as a basis, the following is a suitable syllabus for the four years of the Junior School.

(i) The four rules of addition, subtraction, multiplication, and division used for numbers, money, length, weight, capacity, and time.

(ii) Long multiplication and division of numbers, money, length, weight, capacity, and time.

(iii) Reduction, downward and up-

ward, in connection with the same measures.

(iv) Vulgar fractions, including very simple multiplication and division.

(v) Decimal fractions, with the processes of addition and subtraction only.

(vi) Percentages as another form of fractions, very simply introduced.

(vii) Ruler work. Scale drawing. Map making.

(viii) Mensuration. The areas and volumes of rectangles. The circle.

This syllabus is similar to the one outlined in the previous chapter. It is slightly more comprehensive, and includes those sections of arithmetic with the omission of which my disagreement has already been stated. Early teaching must be objective and related to the child's experience. The teacher must think at the child's mental level. But the objectivity and thinking must not be allowed to produce tedium. I have found a class of eight-year-old children energetically working with delight at long multiplication of money. Certainly they were members of a very bright class, and one would not advocate such work for the average eight-year-olds. But why keep these children back? They were mentally very alert, and very definitely enjoyed this work more than that of their normal simpler syllabus. They could do it, and understood what they were doing.

One must remember the two aims of the teaching, the utilitarian and the cultural. The cultural—the training of the mind in clear, logical thinking—must have its place, so, too, must the practice of accurate and speedy reckoning. The tempo of the teaching of the processes of calculation should be at the rate of the child's mental development. My experience, and therefore my belief, places all the sections of the foregoing syllabus within the capacity of the child during his four years' stay in the Junior School.

The processes of reduction are included because of their use in sums connected with money, measures, and time.

Vulgar fractions, decimals, and percentages are there, because they are part and parcel of the same thing. They are all fractions. There is nothing unnatural in teaching the child to work with fractions. Man early learnt that as he had whole ones, he also had parts of whole ones. The child soon experiences half an apple or an orange, a piece of cake, half a penny, part of a bag of sweets. The child is therefore taught to think numerically concerning those parts. There is no need to restrict him to the one form of writing those parts. When we talk of fractions we naturally think of vulgar fractions. They are so old. Decimal fractions and percentages are manufactures of a very much later date, but they are exceedingly useful manufactures. They should not be withheld from a child's arithmetic syllabus.

Ruler work has more than one utility. It is useful as a practice in accuracy. It is useful as a practical introduction to vulgar and decimal fractions. It must be used when dealing with areas and volumes, and geometrical figures. It is useful in correlation with many other subjects of the curriculum.

Areas and volumes are introduced to give the child an idea of two and three dimensions, and the circle to give the child practice in the use of the compass and the pleasurable occupation of making designs.

This syllabus is used in my *Junior*

Workaday Arithmetics (Cassell), and is split up to form a scheme in the following way. First year, for the age of 7 + :

(*a*) Notation to 99. The four simple rules.

(*b*) Money to 10*s*. Addition and subtraction only.

(*c*) Two to six times tables.

(*d*) Ruler work in inches and half-inches.

(*e*) Shopping sums to 10*s*.

(*f*) Telling the time.

Second year, for the age of 8 + :

(*a*) Notation to 999. The four simple rules.

(*b*) Money to £10. The four simple rules.

(*c*) Length (feet and inches). The four simple rules.

(*d*) Two to twelve times tables.

(*e*) Ruler work in inches, halves, quarters, and eighths.

(*f*) Vulgar fractions introduced in connection with ruler work.

(*g*) Shopping sums to £10.

(*h*) Easy reduction of money.

(*i*) Telling the time.

(*j*) Mensuration — drawing squares and oblongs.

Third year, for the age of 9 + :

(*a*) Notation to 9,999. Money to £100. The four simple rules.

(*b*) Length (yards, feet, and inches), weight (stones, pounds, and ounces), capacity (gallons, quarts, and pints). The four simple rules.

(*c*) Long multiplication and division. Numbers only.

(*d*) Vulgar fractions. Connected with ruler work.

(*e*) Decimal fractions. Connected with ruler work.

(*f*) Shopping sums to £100.

(*g*) Reduction of measures used above.

(*h*) Use of time-tables.

(*i*) Ruler work. Inches, thirds, sixths, twelfths, tenths. Drawing to scale.

(*j*) Mensuration. Areas of squares and oblongs.

Fourth year, for the age of 10 + :

(*a*) Notation to 99,999. Money to £1,000. The four simple rules.

(*b*) Length, weight, capacity, time. The four simple rules.

(*c*) Long multiplication and division of numbers, money, and the four measures of (*b*).

(*d*) Reduction of all measures.

(*e*) Ruler work. Scale drawing. Map making. Geometrical shapes.

(*f*) Vulgar fractions. The four rules using simple fractions.

(*g*) Decimal fractions. Addition and subtraction only.

(*h*) Shopping sums.

(*i*) Percentages simply introduced.

(*j*) Mensuration. Areas and volumes of rectangular figures and shapes. The circle as compass work.

Let us proceed to analyse this scheme.

It will be seen that the whole is carefully graded; for example, in the case of notation the seven-year-olds use number to 99, the eight-year-olds to 999, the nines to 9,999, and the tens to 99,999.

Man took many centuries to count to ten, and many more to group tens until they reached 100. As has been shown, he used pebbles, beads, the fingers, and the abacus, that is, he counted objectively and he computed objectively. With the introduction of the Hindu-Arabic symbols he threw off what he considered to be the incubus of objectivity, and scholastic arithmetic became solely pure mechanical calculation. The heads and leaders of the

schools apparently felt a loss of interest, so they produced ingeniously devised and designed sum-books. But all the artistry in the world cannot develop arithmeticians by the use only of mechanical computations.

During the eighteenth and nineteenth centuries teachers and writers returned to the primitive counting and calculation by the aid of objects. Best known of the teachers was Johann Pestalozzi, and of the writers, Tillick and Grube. Pestalozzi used objects common to the child's experience, including its fingers. He emphasized the need to understand number, rather than the ability to engage in multitudinous manipulations of figures. Therefore he taught the young children in his school to count first and to do simple operations with the numbers from 1 to 10 before he taught them any figures. His older children were adepts at "mental" arithmetic, for, following his ideas of the importance of number over figures, he developed the "mental" to an astonishing degree.

Tillick, agreeing in the main with Pestalozzi, insisted that if tens and units are given thorough and exhaustive attention larger numbers will present no difficulty. He used for his demonstrations a reckoning-chest, which contained what are known as Tillick's blocks, and by which children could perceive the grouping of tens, on which the inventor laid so much stress.

Grube, the writer of *Leitfaden für des Rechnen,* published in 1842, also urged teaching by sense-perception and the handling of objects. He argued that a year was not too long a period in which to teach children to *know* the numbers from 1 to 10. Then for the next two years they ought to be taught, number by number, up to 100. He required this length of time so that experience in the four rules could be gained with each separate number. That is to say, before 35 was treated, all that could be known about the number 34 was known.

From this extravagant insistence on number knowledge, the inevitable reaction followed. There was a return to the old-time mechanical operation, as before described, lengthy and monotonous and interest-killing in the extreme. Our twentieth century is introducing a new arithmetic, combining the objective, the mechanical, and the reasoning, and teaching the science of arithmetic scientifically. Herbert Spencer in his *Education* says, "A common trait of these methods is, that they carry each child's mind through a process like that which the mind of humanity at large has gone through. The truths of number, of form, of relationship in position, were all originally drawn from objects; and to present these truths to the child in the concrete is to let him learn them as the race learnt them. By and by, perhaps, it will be seen that he cannot possibly learn them in any other way; for that if he is made to repeat them as abstractions, the abstractions can have no meaning for him, until he finds that they are simply statements of what he intuitively discerns."

Pestalozzi was a great teacher, and there was very much of value in his methods. The scheme of this chapter agrees to a large extent with his findings. The seven-year-olds are limited in the scheme to numbers less than one hundred, that is, to tens and units. One hundred itself is not included, so that the hundreds place need not be

taught. By using numbers to 99 the children will have a good idea of the size of the numbers they are using. They will be in daily contact with such numbers: it is probable there will be from fifteen to twenty dual desks in the room; the scholars in the class will number from thirty to forty; 25 or more milk-bottles will be brought into the classroom each day; the monitor checking pencils, rulers, or brushes will have to count at least to the thirties; the numbers on hat-pegs will be similar; the pages of the children's reading-books will be numbered to the twenties, or forties, or sixties.

Objection may be made that if children can do processes with tens and units, they can carry the processes on to deal with hundreds without any further difficulty. That is probably true, and the teacher of the eight-year-olds will find it so. Little trouble will be found there in teaching the mechanical extension. But if the First Year pupils are to use hundreds, why stop there? Why not set them sums which include thousands and even millions? In other words, why not give these seven-year-olds for a morning's work a series of sums such as the following?

$$\begin{array}{r} 16\times \\ 6 \\ \hline \end{array} \qquad \begin{array}{r} 345\times \\ 6 \\ \hline \end{array} \qquad \begin{array}{r} 28{,}179\times \\ 6 \\ \hline \end{array} \qquad \begin{array}{r} 4{,}821{,}693\times \\ 6 \\ \hline \end{array}$$

The obvious answer is that they could not possibly appreciate nor find any sense in what they were doing. It would be meaningless drudgery to them. Such sums might have been done quite complacently (but still with no value) generations ago, but the child of today has a vaster outlook, and makes a greater call for interest. The value of the work would be entirely negatived by a complete lack of that interest, and the production would be that of the belt method of the modern industrial concern.

There is another reason for limiting the child of the First Year to work in tens and units. Early man took a long time to count in units and in the grouping of those units. That which gave him trouble will give trouble to the child. Therefore a thorough grounding in units and their first grouping into tens is most necessary. Understanding of the grouping of tens will simplify the understanding of grouping in hundreds. On the other hand, playing with hundreds, thousands, or millions will never give a comprehension of the meaning of number at all.

In the second year the scheme introduces the child to hundreds, in the third to thousands, and in the fourth to tens of thousands.

Another objection may be raised. Can the child of ten comprehend tens of thousands? By the time the boy reaches the school-leaving age of fifteen, he will have to learn of millions. He will not grasp their vastness. But we all, today, have to talk in millions. None of us can visualize such a number. We can see at the Wembley Stadium a crowd of 95,000 spectators. Unless we knew the capacity of the place we could not call on any numerical experience we had ever had to say there were 95,000 present. We might, by computation, arrive at an approximate figure, but a judgment of the number of the crowd would be beyond our capabilities. Yet we read of millions, speak of millions, and think of millions. So, too, will the adolescent if he is to take a lively interest in the vast numerical affairs and undertakings of

his country. It will be necessary, therefore, at some stage in his arithmetical career for him to leave the completely comprehended. How better to prepare for this than to do so step by step?

A similar grading is planned in the scheme for sums dealing with money. In Year I the child is called on to work in amounts up to 10*s*. That will be quite sufficient for him. It is strange that however much children have to do with halfpennies and farthings they find the writing of them difficult. Their use of them as $\frac{1}{4}d.$, $\frac{1}{2}d.$, and $\frac{3}{4}d.$ is probably their first experience of fractions. They seem oddly different from all symbols previously used, and therein is apparently the cause of the hesitancy in their use. Some schemes leave them out until pence, shillings, and pounds have been taught. They should be included in the first steps: pennies and their parts are of the lower values of coins with which children are most familiar. To permit of no strain on these seven-year-olds, the scheme asks for the processes of addition and subtraction only. Simple multiplication and division to amounts not more than £10 are introduced in Year II, and long multiplication and division in Year IV.

Multiplication tables find a place in the work of Years I and II, from 2 to 6 times in the former, and the remainder to 12 times in the latter. There appears to be an amount of controversy about the teaching of these tables; in fact, some would not teach them at all. To my mind, they are the ABC of mathematical calculation. Use what method you will, you must teach a child to recognize the letters of the alphabet in order that he may be able to do that first essential of all education, namely, to read. So with the multiplication tables. Use what method you will, you must see that the child knows the contents of those tables, in order that he may be able to work arithmetically, quickly, and accurately. Spencer has this to say on the point: "The once universal practice of learning by rote is daily falling into discredit. All modern authorities condemn the old mechanical way of teaching the alphabet. The multiplication table is now frequently taught experimentally." It may be well for the child to build up his own tables. In that way he may understand them the better. But he must know them. If there be a royal road to that achievement, well and good! As a practical teacher, I have not found it. It is essential that $6 \times 7 = 42$ is at the child's mental command the instant he requires it. The answer to 6×7 must be automatic. The method used, whatever it may be, must give the child understanding and a complete knowledge of the tables at the earliest possible time and with the least sufficient time spent on them. I am not sure that Montaigne's dictum, "Savoir par cœur n'est pas savoir," is true when applied to multiplication tables.

Throughout the scheme much attention must be paid to number drill and place values. Such work as the following should be of frequent occurrence.

"Write in 2's from 40 to 20, like this: 40, 38, 36 . . .

"39 is . . . tens and . . . units.

"Write in eighths from $\frac{1}{8}$ to 2 units.

"Write in hundreds from 4,426 to 5,126.

"In 4,795 are . . . hundreds.

"In the number 83,692 the thousands

figure is . . ." This type of work has great value. Children need constantly to be reminded that position affects number. On a faultless knowledge of place-values depends so many of the processes they do.

Practical work is introduced into the scheme. In Year I it takes the form of measuring pints and quarts, weighing with pounds and ounces, and telling the time. Spencer refers to this approach. He says: "While the old method of presenting truths in the abstract has been falling out of use, there has been a corresponding adoption of the new method of presenting them in the concrete. The rudimentary facts of exact science are now being learnt by direct intuition, as textures and tastes and colours are learnt. Employing the ball-frame for first lessons in arithmetic exemplifies this. It is well illustrated, too, in Professor De Morgan's mode of explaining the decimal notation. M. Marcel, rightly repudiating the old system of tables, teaches weights and measures by referring to the actual yard and foot, pound and ounce, gallon and quart, and lets the discovery of their relationships be experimental."

Other practical work is done with mathematical instruments. Ruler work takes an important place in the scheme. Its uses have been stated earlier in this chapter. In the first year, the child is asked to use inches and half-inches, and other parts of an inch are systematically added in the second and third year. By the time he reaches the fourth year, and is ready to work vulgar fraction processes, he does not fear fractions. His acquaintance with them has been of long standing.

Graded work with the ruler, with an aim other than that of an introduction to fractions, is planned in this way. In the first and second years lines and various shapes are drawn and measured using inches and parts of inches. In the third year other parts are introduced, including the tenth; puzzles for dissection and for reassembling are drawn, and exercises are set in scale drawing. In the fourth year ruler work is correlated with areas and volumes, and the use of the compass and protractor is introduced.

One or two points of general interest in connection with the scheme should be noted.

Throughout the course children should be taught to check their answers. They should be led to see that the processes they use are not isolated, not unrelated, but that subtraction is simply unadding, that multiplication, as was known to the old abacus computators, is a short way of doing repeated additions, and that division is similarly of repeated subtractions. If children realize these relationships, they will be able to reason how to check their answers. But *to reason* about checking is not sufficient: the *habit* of checking must be formed.

Very easily we write on the blackboard, for small children to do, such sums as this: $6+4-2=$. It is so simple that we take no thought of what we have written. Is it simple to children? Do they really know what $+$, $-$, and $=$ mean? Are they signs, familiar to the children because of their frequent appearance, with little or no meaning? It is worth the while of the teacher to make inquiry. The answers given to the question, "What is the meaning of $+$ and $-$?" will probably

be illuminating. It is absurd to continue using the signs unless the children fully understand their significance. $7 + 9 = 16$ does *not* mean 7 and 9 equal 16. 7 and 9 cannot equal 16. The statement shows that "if 7 and 9 are added together we can group them in a new way, as one ten and six units." $7+9=16$ is a shorthand way of writing that long statement. It is fundamental that children should not only be able to recognize the signs and the processes they signify, but also that they should have clear conceptions of the ideas expressed in the short way. Of course one would not object to children saying that "7 and 9 make 16" as an interpretation of "$7+9=16$." The point is, they must know when they are making the statement what it means. This important matter will be returned to in a later chapter.

Children should so understand the processes they use, that they are continually on the look-out for short cuts. A minimum of working should be their aim, for the less operation there is, the less error is there likely to be. They should at some time during the four years in the Junior School make use of such facts as: pence or inches multiplied by 12 are the same number in shillings or in feet; the reverse is true of division; four threepences make 1*s.*, eight three-halfpences make 1*s.*, and eight half-crowns make £1, are useful when doing reduction or shopping sums; multiplying or dividing by multiples of ten is done by short division, for 0 has a position value only; 99 times a number is 100 times the number less the number once; a number times 9*s.* 11½*d.* is the number times 10*s.* less the number times a ½*d.*; 25 is 100 divided by 4, and 125 is 1,000 divided by 8, and these equalities can shorten multiplication and division; the difference between the two multiplications £2 17*s.* 11*d.* × 31 and £2 17*s.* 11*d.* × 25 is £2 17*s.* 11*d.* × 6.

Great care should be taken in the choice of examples set in working this scheme. There will, of course, be mechanical sums to be done, and there will be word-sums, commonly called "problems." I do not like that word "problems." It is connected in my mind with "problematic," which means, the dictionary says, "questionable" and "doubtful." What could be worse than to suggest to a child that a sum is questionable? There can be no doubt about a sum. It can be done. Therefore I prefer the term "word-sum," but tradition calls it a "problem," and one lone voice cannot alter tradition.

Great care, I repeat, must be taken in the choice of "word-sums." In the first standards they should concern the children, their desks, their milk-bottles, their toys, their indoor games, their school tools, their purchases, and so on. Later should be introduced questions relative to outdoor games such as rounders and cricket, general sports gear, National Savings stamps and certificates, and bus time-tables. In Year IV the children's immediate interests should be left, and application made of their wider interests, such as aeroplane flights, shipping, Test matches, motor-cars, athletic meetings, the football pitch, rail and car journeys, and map-reading. The subjects of the lower classes will bore these developing minds. They must be catered for, and that is no easy matter. The children of 10, as a group, show a greater "'satiable curiosity" than any other group of the

school years. Their interests seem suddenly to broaden to unbounded extents, their minds to become more agile, their hunger for knowledge (like their physical hunger) to be beyond appeasement. So, to hold these children within the boundaries of their limited experience is to kill them educationally.

One other aspect of the scheme of work needs looking into. That is the child's personal part in it. He does practical work, he takes his share in oral work, but he also has to do written work. What standard is expected of him in that written work? Is a standard of production in his exercise book set, and does he know it? Some time ago I had a very interesting and somewhat heated argument with a mathematics master of a Service Technical School in which were students of the age-range of fifteen to eighteen. The question arose as to the setting-out of sums. My colleague informed me that he did not object to a "mass of figures" on the cover of an exercise book or anywhere else. How and where did I do my arithmetical calculations? The answer he received was that he would probably find no envelope or scrap of paper in my pockets but which was covered with scribbled, numerical computations. But I was not learning arithmetic. All the processes were at my command, and the results of examinations proved that was the case. My disagreement with what satisfied him was very emphatic.

The child in the Primary School should be expected to take a great pride in his exercise book. He should be encouraged to keep it a model of neatness. The covers should not be used for "odd" working. The standard of work should be "the best, and nothing but the best."

Why? For the reason that neatness and care mean accuracy, and without accuracy arithmetic is valueless. What is easier than to mistake a badly made 7 for a 1, or a 3 for a 5, or a 6 for a 0? Mistakes are not permissible in arithmetic. Then why allow opportunities for errors to be made?

One of our aims is to teach logical thinking. "Masses of figures" will not aid in attaining that object. For every "word-sum" there should be a set form, consisting of four parts. First should be put in brief what is to be found out. Then should be stated the process to be used. Next should follow the working of the sum, and lastly there should be a brief statement containing the answer and the original question. Consider the sum, "What will 7 dolls cost at 3*s.* 9½*d.* each?" The setting out of this sum should be:

What is the cost?

Multiply.

$$\begin{array}{rrr} £ & s. & d. \\ & 3 & 9\frac{1}{2}\times \\ & & 7 \\ \hline 1 & 6 & 6\frac{1}{2} \\ \hline \end{array}$$

7 dolls will cost £1 6*s.* 6½*d.*

Such a working proves that the child knows what he is doing. Without doubt he is showing that he is learning to reason. A waste of time, you say? Agreed! if the aim of arithmetic be mere mechanical calculation. But Not Agreed! if the aim be the greater one of a comprehension of number and a training in logical thinking.

The answer to every "word-sum" should be as interesting and as logical as a story.

The requirement of neatness from the scholar is accompanied by a similar requirement from the teacher. Both in blackboard work and in the marking of the children's note-books the teacher should exercise the greatest care. His "R" or "X" should accord with the standard asked of the pupils. A certain person, whose work took him into a large number of schools, told me that he could sum up the standard of production of a class by a scrutiny of the teacher's register. Maybe that was somewhat of an exaggeration. What is true is that you, teacher, are the embodiment in many ways of the ideal of the children of your class. In no particular is that more true than in the manner in which you do the things you ask them to do

The success of the scheme then depends on much practical and oral work in the earlier classes, a widening of interest in the later age-groups, a following of the graded development of the subject, exhaustive work in number comprehension, a maintenance of the child's pleasure and interest in the work, an emphasis on mental training both in oral and in written work, and the example of the teacher's accuracy in his oral statements and his care in what he writes.

CHAPTER FIVE

GENERAL PRINCIPLES

NOW that we have come to a conclusion as to the objects of our teaching of arithmetic—although with that conclusion there will undoubtedly be disagreement: for example, David Eugene Smith writes, "It is not at all settled as to what we are seeking in teaching arithmetic to a child"—and have designed a syllabus and a scheme from that syllabus, our next consideration must be the general principles underlying our presentation of the subject.

Let us turn to the writings of that nineteenth-century philosopher, Herbert Spencer. In his *Education* he sums up the principles of all education in these words:

"1. In education we should proceed from the simple to the complex.

"2. The development of the mind, as all other development, is an advance from the indefinite to the definite.

"3. Our lessons ought to start from the concrete and end with the abstract.

"4. The education of the child must accord, both in mode and arrangement, with the education of mankind, considered historically. In other words, the genesis of knowledge in the individual must follow the same course as the genesis of knowledge in the race. In strictness, this principle may be considered as already expressed by implication; since both, being processes of evolution, must conform to the same general laws of evolution, and must therefore agree with each other.

"5. In each branch of instruction we should proceed from the empirical to the rational. During human progress, every science is evolved out of its corresponding art.

"6. In education the process of self-development should be encouraged to the uttermost.

"7. As a final test by which to judge any plan of culture should come the question, 'Does it create a pleasurable excitement in the pupils?'"

If we accept that statement of principles (or any other), a new problem confronts us. What methods shall we employ to put them into practice?

During the last two and a half centuries very many methods have been planned and offered to the teachers of arithmetic. That is all to the good. The attention paid to our subject proves its importance. Maybe we should not rank its importance as high as did Pythagoras, for he said that numbers were the very substance of which all things are made. More likely are we to agree with Bacon, who wrote, "There remaineth yet another part of natural philosophy, which is mathematic. The subject of it being quantity, not quantity indefinite, but quantity determined or proportionable, it appeareth to be one of the essential forms of things, as that that is causa-

tive of a number of effects. It is true also that of all other forms (as we understand forms) it is the most abstracted and separable from matter, and therefore most proper to metaphysic; which hath likewise been the cause why it hath been better laboured and inquired than any of the other forms, which are more immersed into matter." Arithmetic is one of the most useful and important of our curriculum subjects. It is a matter of regret to me, personally, that, whereas in the *Handbook of Suggestions* of 1927 arithmetic was the fourth subject in the order of treatment, in the revised 1937 edition mathematics was relegated to the last place, the eleventh. Perhaps it was a matter of keeping the best to the last, but "man at the beginning doth set forth good wine."

The method makers, both the theorists and the practitioners, have never felt satisfied. They remind us of the ancient Greek philosophers in their search for the Absolute. Thales plumped for water, Anaximenes for air, Xenophanes for earth, Heraclitus for fire. Their arguments were ceaseless. Holmes, in his *Poet at the Breakfast Table,* remarks that "the worst of a modern stylish mansion is, that it has no place for ghosts." The building of arithmetic is no modern piece of architecture, but is as ancient as man. It is very full of ghosts, the ghosts of dead methods. It does not matter that those methods are dead. The important fact is that they once existed, for as the varying theories of the old philosophers kept the question of First Principles ever in the mind of thinking Greece, so formulation of these methods has kept alive and alert the minds of the teachers of arithmetic.

Here are some specimens of "methods" proposed or used by teachers and theorists interested in mathematics.

In 1586 Simon Stevinus published a pamphlet the title of which (in the English translation) was. *Disme: The Art of Tenths, or Decimall Arithmetike, teaching how to perform all computations whatsoever .by whole numbers without fractions, by the Four Principles of Common Arithmetike, namely, Addition, Subtraction, Multiplication, and Division.*

Dr. Kinner evidently combined arithmetic with the mother tongue, for in his *Delineation,* 1648, he says, "Because Arithmeticall cyphers are numbring words I teach to write and pronounce them also, and to tell the values of many of them, placed in a certain order, which we call Numeration."

Pestalozzi introduced the "concrete" approach, but he proceeded much too quickly to engage his pupils in immense abstract mental calculations. His may be termed a "unit" method, for he instilled in his scholars the fact that all numbers are multiples of "one."

Tillick's work was much narrowed by concentration on the use of his "blocks."

Grube's method was a concentric or spiral one, for ideas formed and processes taught were enlarged to agree with the developing powers of the scholar. He failed in that he foolishly restricted progress to one number at a time.

Of more recent writers, David Eugene Smith, in *The Teaching of Arithmetic,* seems to favour the "topic" method, for he says, "There is the topical

arithmetic, that is a book arranged by topics, a subject like percentage being taken once for all, the pupils studying it until it is thoroughly mastered. Such a book has two great merits: it tends to keep the child upon each subject long enough to give him a feeling of mastery that he would not have if he studied some of the scrappy books constructed on the extreme spiral system." But later he says, "No extreme of 'method' should be adopted by any teacher or school, but the best of every 'method' should be known as far as possible to all."

McLellan and Dewey, in *The Psychology of Number,* would base arithmetic teaching on measuring, for they say, "When we count we measure," and "when we measure we count." Again, "The method which neglects to recognize number as measurement (or definition of the numerical value of a given magnitude) and considers it simply as a plurality of fixed units, necessarily leads to exhausting and meaningless mechanical drill."

There has lately come to my hand a comparatively recent book. Written by B. Branford, and called *A Study of Mathematical Education,* it was published by the Clarendon Press in 1908. In it the author presents a new method. He writes, "The teacher will observe throughout the lectures that the dominant stress has been laid upon geometry in the teaching of mathematics." There is no doubt at all that the author is very impressed by the possibilities of that method. But, like all methods creators, he sees proof of the rightness of his method in everything around. Concerning a child's remark, "A thick piece of bread with plenty of jam spread on the top," he says, "Here we have six references to geometry. In such sentences we note the wonderful complexity of geometrical ideas attainable by mere infants." There may be truth in that analysis of the child's words; to my mind the infant's ideas were not geometrical, but visual and stomachic.

I would not have it inferred that I am decrying Mr. Branford's method. His book is excellent: his method may be likewise. The results of any systematic use of it have not, as far as I know, been published. My point is that methods can be laboured to an extent that is astonishing.

Sufficient have been the "methods" recalled for it to be realized that "of the making of methods there is no end." Anyone sufficiently interested can choose a central idea and around it produce a mode of procedure. With his method the creator may be entirely successful. Another teacher using the same method may be utterly and entirely unsuccessful. Each teacher, basing his work on broad, tried principles, must produce his own method.

The reader will logically ask, "But suppose my class is using a certain text-book, do I not follow the method of that text-book?" An answer to the query is, "Text-books were made for man, not man for text-books." However good the text-book may be, it cannot be perfect. For one thing, head teachers have to consider school stationery allowances, which fact is reflected in publisher's production costs, and they in turn restrict book sizes. An author has, therefore, to cramp his matter into a certain number of pages, or, if he objects to cramping, to leave out matter which he thinks to be indispensable. No! your school arithmetic cannot be

completely and satisfactorily a finished article. It is for your help, to a great extent for your guidance, but it should not be your master.

Many good sets of graded text-books are now available. Some of them have been produced with much care. Of one I know that it was the result of the cumulative experience of twenty years' teaching of the subject, and the actual writing of it took four years. Even with that amount of preparation and thought the book has its faults, fully realized by the author. A teacher should not stick slavishly to any text-book. Every sequence of new subjects may not be to his liking, and the "word-sums" in it may be improved for the teacher's own particular school by the introduction of topics of local industrial interest.

It would appear, then, that it is not the method but the general principles behind the method on which stress must be laid. Let us return, therefore, to the principles of Herbert Spencer, listed at the opening of this chapter.

The first principle that "we should proceed from the simple to the complex" is not as self-evident as its first reading would leave it. Who is to assess the "simple" and the "complex"? Is it the teacher? Much to him is "simple." But to the small child? Is anything "simple" to him? Or is it that everything is? Everything, that is, that is objectively perceived. It must be so, for he lacks abstract ideas concerning what he sees, and it is the accumulation of the abstracts which give rise to the complexity. Hence we must beware what we term "simple." An orange to a child is a simple object. So are the three sections of that orange given him as his share of it. But $3/8$ of that orange most certainly are not. Complexity arises from having three pieces of parts called eighths. Take away the orange and the abstract $3/8$ create greater complexity still. To a boy of ten, both the $3/8$ of the orange and the abstract $3/8$ are within his power of comprehension. To him they are "simple." Therefore, in accepting this first principle one must consider the child. It is a matter of psychology.

The second principle states that "the development of the mind is an advance from the indefinite to the definite." The statement is perfectly true, but it is not a principle of teaching. Because a child talks first of "few, much, lots, shorter, many people," and later can comprehend "3, 2 lb., 749, 4 inches, an audience of 50," we are told we must teach him in an indefinite manner. Spencer goes on to say, "It is not practicable to put precise ideas into the undeveloped mind." It is! It must be! The more precise the better! Nothing we teach should be hazy, indefinite, inexact. Arithmetic is an exact science, the most exact of all the sciences. How can a mind develop on indefinitenesses? When does the teaching become definite? As long as there is an undeveloped mind we must refrain from precise ideas! Therefore in the Primary School no precise ideas must ever be given! How absurd!

The third principle says that our lessons ought to start from the concrete and end with the abstract. That statement is quite easily made and sounds to be common sense. But as a teaching maxim it requires analysis. What is meant by the concrete? Surely that which can be known by the senses, that which is objective, that which is exterior to the mind. From that concrete, that

object outside the mind, the child is to think subjectively. But before he can do that he must have the concrete firmly in his mind. It is not enough that he has seen some object, he must have comprehended some fact concerning it. Can we be sure he has done so? Suppose a child is being taught to recognize "three," and for the purpose he is given three bricks coloured red. From those three red bricks can it be certain that he has a mental idea of "three"? Or has he been thinking of them as pieces of wood painted brightly, as pretty bricks, as bricks with lots of sides, as small bricks, as bricks the same size, as bricks with which one can build, and so forth? The child's sense-perception of the concrete must be followed by a perfect mental grasping of the concrete, before his mind can perform abstract processes. It has to be realized that the trained adult can analyse and discriminate between the qualities of the concrete. The untrained child cannot. The process must be: the concrete, the concrete in the mind, the abstract.

It would be preferable to say that our schemes of teaching should start from the concrete than that our *lessons* should. Spencer's principle cannot possibly be true of all our lessons. One other point on this third principle. One aim of teaching arithmetic is to enable a child to apply his numerical skill "intelligently, speedily and accurately in the solution of everyday problems." Thus the end of our work is not abstract but concrete. Therefore if we start with the concrete and pass to the abstract, we return again to the concrete, having increased and perfected ideas by means of the abstract to tackle the more complex concrete.

With the fourth principle of the historical treatment we are in general agreement, with the reservation, as has been noted before, that there shall not be exact parallelism. We would not teach the child all the schemes of symbols that have been used so that he should know our own; nor would we teach him the "scratch" method of dividing in anticipation of the present-day method; nor would we use the abacus and teach compound multiplication by a process of continued addition. Common sense will omit the obsolete and useless. But the main course of the evolution of the subject is psychologically the correct one to use.

"In each branch of instruction we should proceed from the empirical to the rational." Such is the fifth principle, and it is a true one. Aristotle agrees when he says, "All science may be taught, and all teaching implies principles, namely, those truths which are previously known by experience or reason. The first principles are acquired by induction, that is, by intellect operating on experience." What value can accrue from teaching a class "acres" if no member of the class has ever "experienced" acres? The pupils may do endless sums relative to such an area, and yet know not whether it be the area of a city, a village, or a pig-sty. Their work will only prove that they either have or have not learnt the square-measure table, and can or cannot manage the four rules. Treat the area empirically first, then let the reasoning about it be done afterwards. What is the area of the school property? Does it cover $\frac{1}{2}$, 1, 2, 10 acres? What is the area of the school garden? What length of the street near the school covers an acre? How much of

the public park constitutes an acre? Let the children measure an acre there and see the area of it for themselves. On such empirical knowledge can correct ideas be formed and sound reasoning will follow. How can there be faultless mental processes about that which is not comprehended?

The sixth principle—"the process of self-development should be encouraged to the uttermost"—is an essential one. As stated here, it presupposes two partners in the business of education, one who is to "self-develop" and one who is to "encourage." The partners are the learner and the teacher. It is the work of the latter to "draw out from" and not to "pump into" the former. The days of inanimate, dead-level, monotonous "grind" and "list-memorization" are passing: no longer do we believe that the teacher's job is to lecture and the child's passively to imbibe. The teacher of today feels that as an educator he must be an encourager, a guide. He realizes that the child cannot know what is best for it to learn. So comes the necessity for his guiding mind. He disbelieves that he has to tell children everything; he believes he has to tell them as little as possible. He wants them to develop, and he believes they do that largely of themselves. But he still has to agree that Goethe was right when he said, "We must all receive and learn both from those who were before us and from those who are with us. Even the greatest genius would not go far if he tried to owe everything to his own internal self." The teacher's creed is this-wise: he must guide children to investigate and so gain experience; accumulated experiences result in knowledge; the greater the knowledge the more exact and perfect are ideas; the greater is mental development; the more can children reason; the more are they able to think for themselves.

That is one of the great aims of education—to get children to be able to think. Those old, stilted, dry-as-dust, mass-production methods produced a nation of Englishmen who, in the main, were comfortably contented to follow the crowd. Bertrand Russell was perfectly correct when, in 1922, he wrote, "Our system of education turns young people out of the schools able to read, but for the most part unable to weigh evidence or to form an independent opinion." Counting and performing arithmetical processes do not call for high mental development. They are so mechanical. In fact, if our number work is entirely computative, our work is retrogressive. It required far greater intelligence for an uncivilized shepherd to recognize individually his sheep and to know if there should be one missing, than for a modern shepherd to count his sheep to ensure a full tally. It required far greater mental agility for the village carrier to carry out commissions for all and sundry by the use of memory only, than for the modern grocer to tot up the customer's account. The mere written calculations of the classroom do not signify great mental development. The improved methods are showing some results. There is a greater average power of thinking in the young adult life of the last ten years. But still much, very much, remains to be done. Recently I tested a class of forty ten-year-old children with the simple question, "What do you mean exactly by $3+5=8$?" No pre-view of the question was granted,

no discussion was permitted, no help was given. Thirty-two of the children wrote for the answer, "Addition," "You add up," or "Addition of numbers." One answer was, "Three and five added together = 8," and another, "It means that 3 plus 5 equals 8." The only really satisfactory answer was, "If you add 3 and 5 together they make 8, or 3 plus 5 equals 8." These children were all intelligent and produced daily apparently satisfactory arithmetic. But the simple writing of the meaning of the statement they had been in the habit of using for at least four years was quite beyond them. Here was a request they had not previously experienced, and seemingly on no experience could they draw for an answer. In other words, they had been doing a style of sum they did not thoroughly comprehend. They knew how to do the sum, they had been taught how to do it, but the teaching had not led them to think about what they were doing. The encouragement of self-development is an essential principle of teaching, for the adult must comprehend, must be able to reason, and must have confidence in himself that he can with certainty follow his reasoning.

In a previous chapter the statement was made that children must be interested in their work. That fact is the substance of Spencer's seventh principle. Somewhere—I forget where—I have read that it is questionable whether the terminology Spencer uses in this principle is quite adequate. He talks of "pleasurable excitement." The writer inquired if an atmosphere of "excitement" would be conducive to real thoughtful work. Does that excitement rather suggest a birthday party, or a visit to the pantomime or the circus? The word "excitement" may give an idea of "effervescence," but extravagance in that direction is preferable to inertia. There should be a fever for lessons, and it should be infectious. Some years ago I took a Concert Party to entertain the men at a Workhouse. We had some excellent vocalists, instrumentalists, and comedians. But not one iota of response could we get from any one man by humour, by light music, by farce, or by any other item of a two-hours' most energetic programme. The face of every man would have delighted an artist seeking a model for a sphinx. I have seen a similar response from children during a lesson. There was no interest, no pleasure, no effort, no life: neither was there unruly behaviour. I much prefer pleasurable excitement, bubbling activity, sparking eyes, voluntary delight.

It is not an easy matter to state in clear, indisputable definition the general principles which underlie successful teaching. As related to arithmetic I would set them out in this way.

I. The child is the one being educated, therefore the child must be known, which is to say, he must be studied psychologically.

(*a*) The beginning of knowledge is empirical. It grows by mental processes working on experiences.

(*b*) The child can only comprehend that which accords with the stage of his mental development.

(*c*) Broadly, there should be parallelism between the course of the child's growth of knowledge in a subject and of that of the human race.

(*d*) The only true development is self-development, and that should be encouraged to the utmost.

II. The child must be led by the teacher to feel the need for number knowledge, and be inspired to find pleasurable interest in it. As are included in history the main steps of social progress, in geography the unfolding of the world by discoverers, in music the work of the master composers, so in arithmetic should be included an outline of the steps in the progress of that subject. The child should be taught at appropriate times in his school life of humanity's efforts to understand and to use numbers, thus will he realize that he is dealing with an age-old necessity, a very real and vital one, and thus will his interest in it be enhanced.

III. It must be realized that number is abstract, and not a sense-perception.

IV. Arithmetic is a science, and all the facts concerning numbers and the processes in which they are used are not isolated facts and processes but are closely related and form one unified whole.

Whatever method the teacher may employ, that method must not violate those principles. They consider the child, the one to be developed. They consider arithmetic, the subject to be taught. They link the two.

Let us now consider some other important aspects of method.

First, what shall be the course of an individual lesson? My college days taught me that each lesson should consist of at least the four parts, "Preparation, Presentation, Application, Recapitulation." My early note-books were models of exemplification of this stereotyped formula. But experience soon showed that it wouldn't work. It was impressed on my mind that the first section was of infinite importance. Unless in that section interest were obtained, the lesson would be a complete failure. So with great energy startling devices for catching the child's interest were devised. Often the result was a magnificent preparation for the presentation of—no presentation. There was no time for it!

Experience now says that the teacher should get to the subject with the least possible delay. If the lesson needs an immense amount of "preparation," i.e. of leading up to the subject, then the lesson is out of place, out of progression. All that should be necessary is to pick up the threads of the previous lesson.

On occasion, where material is to hand, where it fits into the scheme without being forced into it, the preparation should take the form of reference to the historical development of, or the work of some arithmetician of old times relative to, the new work to be considered. For example, one of the stories from Smith's *Number Stories of Long Ago* would be excellent material for such a purpose.

It is not apparent that "presentation, application, and recapitulation," if of value in other lessons, can be of much value in the teaching of arithmetic. A much more important division of the arithmetic lesson must be considered in terms of the four types of work that the children do, namely, oral arithmetic, mental arithmetic, written arithmetic, and practical arithmetic. By "oral arithmetic" is meant the entire class working of some process orally or the answering of questions for the appreciation of some important point; by "mental arithmetic" the answering in writing of a set of small-numbered

sums worked mentally; by "practical arithmetic" such exercises as measuring and weighing. "Written arithmetic" is self-explanatory.

It is with "oral" and "mental" work that we would deal now; the "written" and "practical" will be discussed very fully in subsequent chapters. Although "oral" arithmetic is mental, and "mental" arithmetic is largely oral, for the purpose of this discussion it is needful to differentiate them.

"Oral" arithmetic is a necessary part of the scheme of work. Suppose one is introducing the methods of addition and subtraction of vulgar fractions, the whole class should be engaged on the work orally. By question and answer, by suggestions from children, by the questions of the children the process will be obtained. Forty heads are better than one. Mutual oral help is invaluable.

To carry this point farther and to make it practical, let us presume the course of the lesson. The teacher commences: "This lesson is to find out the methods of adding and subtracting fractions. Has anyone ever added any fractions?" Surely some pupil in the class will offer the answer: "Yes, sir! when I added farthings together."

The teacher will proceed to write on the blackboard some such sum as $\frac{1}{4}d. + \frac{1}{2}d.$ By question the class will realize that the $\frac{1}{2}d.$ was changed to 2 farthings, and the sum will then be written as $\frac{1}{4}d. + \frac{2}{4}d.$, and the fact of the necessity for changing vulgar fractions to the same "name" will have been established.

It is probable that some other child will realize that he had used fractions when doing ruler work. (He should have done by this stage in his work.) The teacher can then make an inquiry such as: "What one part of the ruler might be used to draw a line of $\frac{1}{2}$ inch and add to it $\frac{3}{8}$ of an inch?"

Thus communally the class would produce the new method it was necessary for them to know. "Oral" arithmetic has a great teaching value.

The question arises as to what portion of a lesson should be devoted to it. If the lesson be of fifty minutes' duration, then very definitely not the whole of the fifty minutes. Although many children never seem to tire of asking questions, they tire of answering them. Fifty minutes of oral work will produce boredom. It should be followed in the same lesson by practical or written work.

"Mental" work, i.e. the written answers to short questions, should be done for five minutes or so daily. Historically it preceded written work by untold centuries.

This work has many values. It is used (*a*) to prepare for the greater use of mental over written work by the average person in adult everyday life, (*b*) to revise work done, (*c*) to prepare in a simple way for new types of work to be done, (*d*) to practise "short cuts," emphasizing such useful knowledge as 20 articles at 2/- each are £2, (*e*) to assist in forming "habits," (*f*) to solve easy problems leading to similar but greater problems in the written part of the lesson.

The point (*e*) needs clarification and emphasis. It should be a habit of the child to perform operations mentally whenever possible. In his written work, whatever can be done mentally should be so done. His slogan should be "never to put on paper what can be

done in the head." Again, multiplication, addition, and subtraction tables should be "habits." A child must not hesitate in giving the answer to such as $9+7$, or $8-3$, or 4×8. Such table work must be done with as little mental effort as is needed to tie up a shoe, to walk downstairs, to close a door. Constant practice will assist in forming these essential habits.

That this mental work shall be of full value, it must be carefully prepared. Haphazard choice of questions will never attain the ends in view. To fit requirements exactly it may be necessary for the teacher to think out his own ten or twelve questions, but he may find a text-book that will provide the material he needs. Some excellent ones have been published.

It is suggested that the "mental" period be not more than five minutes. Very concentrated effort is needed during that time, and five minutes is long enough for such effort to be sustained. To call out that effort the sums set should be short, taken rapidly, dictated once only, and be of varied types.

Children become very keen on this five-minutes' "drill," especially if a chart of the daily winner be displayed, or if each child makes a form of record graph of his results.

Summing up this chapter, we find it is necessary that psychologically sound educational principles should determine our teaching of arithmetic, that on these principles should be founded our personal method of work, and that the constituent parts of our method should be four, namely, oral, mental, practical, and written work.

CHAPTER SIX

NUMBER AND THE FOUR PROCESSES

THERE can be no doubt that the development of the science of number constitutes one of the wonders of the world. From the building of the great Pyramids of Egypt, so astonishingly accurate because some mathematician found that the sides of the right-angled triangle he had drawn were in the ratio of 3, 4, and 5, to the modern marvel of television and the devilish destructibility of the atomic bomb, scientific advance has been made *possible by the perfecting of number.* Consider what invention you will, and at the basis of it you will discover the work of the mathematician. The motor-car, the aeroplane, the refrigerator, the grid system of electrical distribution, the ciné light and sound projector, radar, the transforming of heat energy into mechanical energy, all depend on numerical calculation. The astronomer in his studies of the bodies in the depths of space calculates; the doctor taking your blood-count calculates; the polar explorer calculates; the producer of a new radio valve calculates; the military commander planning a D-day offensive calculates; and so on.

It is remarkable that man worked on this problem of number and solved it, while social difficulties he left unsolved. Julius Cæsar came to Britain because of food and labour shortage—two problems that are still with us. The Norsemen left their homeland in the year A.D. 1000 because of lack of living space: a twentieth-century world war is caused because of a cry for *lebensraum*. Why the intense attention to such an insignificant matter as number? Maybe, because it was a personal matter. As possessions increased, indefiniteness was dangerous to one's belongings. Maybe, again, it was because a consideration of number provided philosophical food, and a percentage of men in all ages *have found pleasure in thinking.* Whatever the reason, men became number scientists and revolutionized the world.

It is our work as teachers of arithmetic to introduce to our pupils this eighth, and possibly greatest, wonder of the world, this science of number. A humble introduction it must perforce be, but a none the less important one, for, as we have said, we shall use the science as a means of instruction in logical thinking, and our hope shall be that the interest we create will cause the study to be pursued when the pupil shall have left the four walls of the school.

What is this "number" which the world finds of such immense value? How can it be explained? The dictionary defines it as "that by which things are counted or computed; a unit of counting; the measure of multiplicity." The first part of that definition

gives the usually accepted explanation. It is a means of counting. With the introduction of number, vagueness gave place to definiteness. The old savage saw herds of wild animals: their magnitude was beyond his ken—they were "many." The modern savage in Australia probably sees herds of kangaroos, or in South America flocks of wild birds; still their magnitude is a vague "many" or "heaps." To us their magnitude is not vague, for number is at our command. We can count the herds, the flocks, with exactness.

But there is more in number than mere counting. To say that in a field there are 78 sheep signifies more than the fact that someone has counted to 78. Behind the 78 is the idea that someone has said, "Taking one sheep as a unit, in this quantity of sheep are 78 units." In other words, he has made a measurement of the flock. And that is the basic fact of the science, the basic fact of number. To comprehend number it must be realized that we are dealing with a measure. Number is not a thing: it is not the name of a thing. If 20 beads are counted, and then recounted for checking purposes, what was number 4 bead in the first counting may be number 14 in the second. It is the same bead, and neither 4 nor 14 can be attached to it. Neither can designate it. Number is abstract. Number cannot be attached to an object. It cannot be perceived. It is a conception.

What makes it possible for this abstraction, this number, to be taught to a child? It is by reason of the fact that the child has an instinct for number. It fascinates him. His intuition will lead him to perform the fundamental process of arithmetic, that is, to count. But after that he will require guidance, much patient guidance, before he is fully conscious of number. But he will offer no barrier to that guidance, rather will his innate interest in number welcome it.

While his interest lasts there will be no bar to progress; it is the task of the teacher to maintain that interest by the use of methods which accord with and are not contrary to the psychological development of the pupil.

The working of the mind in scientific investigation is in this wise. From the observation and handling of external things we gain experience through the activity of the sense-organs, which are composed of sense-cells. The sense-organs are connected in the brain with sense-centres, composed of ganglionic cells. The sense experiences transmitted to the brain are there moulded into ideas. There follow then higher cerebral workings through which, by the association of the ideas, concepts are formed, abstract thought takes place, and steps of reasoning are taken.

Thus the child must first have sense experiences. He must perform very many operations with very many objects before it can be assumed that his brain processes have moulded a mass of ideas and that he is mentally developed for numerical abstraction. No method ever devised can force him to form concepts of number. He will have to take his own time before he realizes that number is a thing apart from the one, two, three objects he counts It need not be that during this period of passing from perception to conception the child does no mechanical drill. The opposite is the case. He should do much, for the greater the knowledge of number he possesses the quicker will he be able to think in

number. But it must not be that his interest is deadened by too early a call on that numerical abstraction which he is incapable of doing.

What besides his counting should the child do? He should be taught to analyse simple numbers. In dealing with 5, he should see that 5 beads are one more than 4 beads, and that 5 buttons are one less than 6 buttons; that 3 sticks and 2 sticks make 5 sticks, and 2 beans and 3 beans make 5 beans; that 4 shells and 1 shell make 5 shells, and 1 brick and 4 bricks make 5 bricks. All these operations must be carried out objectively to gain sense experience. It will probably be necessary to do them in a similar way in the early years of the Primary School, especially where there are "streams" of less intelligent children.

It was thought at one time that before a child could proceed from a number to the next higher one, he must have analysed it thoroughly and exhaustively. He was expected to "know" that number. How tedious, how slow, how unnatural must such a method have been! Psychology has proved that method to be completely wrong, wrong for at least two reasons. First, there was the attempt to force the child to comprehend fully that which by him could be but very dimly understood. Then, working for a whole year on a very few numbers stifled and frustrated him, and the interest, so necessary to be evoked and to be maintained, was entirely lost. One realizes that "making haste slowly" is the only sure means to success, but there is a difference between steady working with pleasurable variety, and slow working with the drudgery of monotony.

In this analysis of simple numbers, three important points should be emphasized as early as possible. They will much accelerate the formation of ideas of number and the final concept of it. To get to "6" the child will have counted one, two, three, etc. He must be led away from that counting, from the thought that 6 is obtained by repeating a series. He must be aided to recognize 6 as a whole. That is the point, the realization that 6 is an entity, a whole in itself, and not a piling up of six separate ones. The second point to be learned is that 6 can be made of 3 times 2, that is, that not only can 6 be built up of ones, but it can be broken into parts within itself, that there are parts within the whole. The third point of emphasis is that as 6 is made of 3 times 2, it is also made of 2 times 3, and that as it is 4 and 2 it also is 2 and 4. Those three points are fundamental in the forming of concepts of number. Emphasis should be laid upon them not only in the Infants' School but also in the first years of the Primary Department. Summarized they are (*a*) numbers are entities, (*b*) they have parts, and (*c*) the parts are interchangeable.

To show in a practical way the entity of number, let the class in the handwork lesson mould in Plasticine a bird's nest and, say, six eggs. Then in the number lesson the child can be led to see that the eggs in the nest form one family of eggs. Certainly there will be six separate eggs, but placed within the bounds of the nest it will be more apparent that they form one complete whole. Similar work can be done with a number of metal soldiers in a fort, toy farm animals—cows, sheep, or horses—in a field, marbles in a ring or small hoop, bulbs in a bowl, and so on.

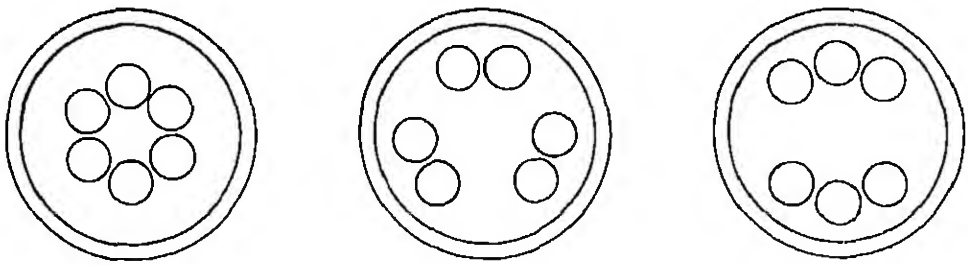


Fig 6—Three Important Points: (a) a Number is a whole; (b) it has parts; (c) the parts can be interchanged

The idea is to place the objects within a boundary, cut off from all exterior objects. There will be a readier appreciation of the fact of entity than if six sticks or beads were laid along a desk.

The facts of parts of the six can be demonstrated by the moving of some of the objects, and so, too, can the connection between 3 times 2 and 2 times 3, and 4 and 2 and the reverse grouping of 2 and 4 (Fig. 6).

The idea can be further developed for various numbers by correlation with nature study. The entity of 3 could be the brood of the three rather large white eggs of the Tawny Owl, of 5 the five fairly large blue eggs of the Song Thrush or the smaller blue eggs of the Hedge Sparrow, of 6 the six small mottled red eggs of the Robin, of 8 the eight tiny white eggs of Jenny Wren, of 12 the twelve rather small light and reddish mottled eggs of the Blue Titmouse or Tomtit.

Let us give further consideration to number as a measure. In using number we do not only the fundamental arithmetical operation, counting, but also the operations of addition, subtraction, multiplication, and division. In what order should these four operations be taught? Old methods taught them to the child simultaneously. Were the old methods correct?

It is said that the young mind has the power of analysis but not of synthesis. It can take the whole and see parts in that whole, but it cannot build up a whole if given parts. If that is so, then logically the analytic processes of division and subtraction should precede those of multiplication and addition. But the facts of analysis and synthesis are not the only ones to be considered. There come into the problem the comparative difficulties of the four operations. The demand on the consciousness is less in the case of addition and subtraction than in multiplication and division, for these last are more complex, as will be seen later. Psychology determines that the child can more easily understand the process of addition and its inverse subtraction, than that of multiplication and its inverse division. Therefore the order should be addition, subtraction, multiplication, division.

The four operations must not be thought of and taught as isolated units of arithmetic. In the previous chapter, the fourth principle underlying the teaching of arithmetic was formulated in this way. "Arithmetic is a science, and all the facts concerning numbers

and the processes in which they are used are not isolated facts and processes, but are closely connected and form one unified whole."

Before that principle can be used there must be awareness of the relationship between the processes. What is that relationship? How can it be expressed? It is of two degrees. First, there is what might be termed the arithmetical relationship. In the simple act of counting, the four processes are implied. Suppose a child has to count a number of pencils. When he has counted 8, he has really been adding. When he had reached 7, one less than the total counted, there was the implication of subtraction. He has taken one eight times, and he has therefore multiplied. In the separate ones of the eight, in the parts of the eight, division is implied. Thus there is a relationship between the processes in the very nature of number. When we consider number as an abstract, as not a thing, as a mental act, as a measure of quantity, a second relationship becomes apparent. It is a psychological relationship. The more simple of the processes are addition and subtraction. The aggregation of the measurements of two or more quantities gives the idea of addition, the comparison of two measurements that of subtraction. Allied to addition and growing out of it, but demanding a more complex conception, is multiplication. Here enters the idea of ratio, of the factor between the two quantities. Similarly allied to subtraction is division, where again the ratio or factor idea requires a greater mental development. An inquiry into the differences between the operations will probably emphasize the relationships. In addition, we find the aggregation of things which are similar and related in some particular. In multiplication the aggregation is of things more than related: they are equal and exactly alike. Suppose before us on a table is a heap of mixed coins, the total of which is to be ascertained. We take a handful, count them and find there are 27. In a second handful are 23, in a third 28, and so on. The addition of these numbers will give us our required total of, say, 150 coins, similar in that they are all legal tender, but not exactly alike in that their face value varies. Let us total these coins by the method of multiplication. We count 10 coins and make a heap of them. We repeat the process until all the coins have been dealt with. It is found that there are 15 heaps of 10 coins in a heap, and we say—

In 1 heap are 10 coins.
In 15 heaps are 150 coins.

We no longer are dealing with similar coins: we are considering equal heaps. Each heap is 10 coins. It matters not the value of the separate coins in the heaps. The point at issue is that there are exactly 10 of them. Every heap has 10. Thus there is equality in all the heaps. Therein lies the difference between addition and multiplication. In multiplication we *times* exactness and equality. The difference between subtraction and division can be similarly discussed.

Let us further consider this psychological relationship in another way. Number measures quantity. A quantity can be measured by means of one of two kinds of unit, (*a*) a unit that is itself not measured, and (*b*) a unit that is itself measured. Reverting to our heap of coins, we can by counting

measure their totality, irrespective of their individual value. We can say the heap contains 150 coins. Such measuring is of the first type. We can then make piles of different denominations from the heap, and measure them by the units of a penny, threepence, sixpence, shilling, etc. We can say there are 19 pennies, 5 threepences, 14 sixpences, and so on, and that the total value is £4 13*s.* 10*d.* Such measuring will be of the second type.

Measuring by the unmeasured unit is used in the processes of addition and subtraction. We say there is a total of 78 sheep or of 150 mixed coins. In those totals we have obtained an aggregation, a relative measurement, a moreness or lessness, an idea of a larger or smaller number. The 78 sheep will be similar, but not all equal. Some may be fat, some thin, a few black, most white, some taller, some shorter. So, too, with the coins. Some will be brown, some white, some round, some twelve-cornered, some larger, some smaller. But when a measured unit is used, there must be equality. The 19 pennies will all be equal, and their total value will be 19 times the measured unit of one penny; the 5 threepences will also all be equal, and their total value 5 times the measured value of threepence; so with the sixpences. It will be seen that this measured unit gives rise to multiplication (and to division), and with it will be a greater exactness of result. The knowledge of £4 13*s.* 10*d.* is more exact than that of 150 coins. So would be the knowledge of the sheep if, instead of being numbered as 78, their weight could be stated as so many pounds or hundredweights.

Thus we see the relationships between the four processes, of multiplication and division growing out of addition and subtraction, but developing further to more exactness, because of the inclusion in their working of ratio and the factor, which are missing from the processes of addition and subtraction. Thus we see also that it is psychologically sound to teach addition and subtraction before multiplication and division.

But simple exercises in multiplication and division should not be withheld until there is perfect mastery of addition and subtraction, that is, until the child can successfully add and subtract numbers of high grade. Although the child mind may not grasp the subtler conception of ratio, factor, or times, he may successfully do simple sums involving the processes of multiplication and division. As has been said, these processes are implied in the act of counting. There is no reason why the child, before he has mastered the art of adding and subtracting tens of thousands, should not count 9 sticks, and then place them in 3 threes, and so learn that 3 taken three times make 9, or count 10 sticks and divide them into fives, thus learning that $10 \div 2 = 5$. Objectively he can do those operations, although subjectively he has no notion of the meaning of ratio. But objective practice will help the child the more easily to seize on the more complex principle of ratio when it shall be presented to him.

Let us now sum up, in the light of the discussion of this chapter, what exactly constitutes the various processes of arithmetic.

The fundamental process of counting is the simplest form of measurement. By counting, the vagueness of "many" is changed to a definite measured quan-

tity. The measurement is based on the unit of unity, whatever that may be.

The process of addition is in essence shortened counting. If we, for example, add together 57 and 93, we are in effect counting to 57, and then counting on for a further 93, and reaching the quantity of 150. Because of this likeness to counting, children find addition the simplest of the formal processes of arithmetic. The measuring unit is again unity. Addition is a synthetic process, a building up a whole from parts.

Subtraction, the inverse of addition, is a shortened backward counting. We start with, say, 150, and having to take away 93, we in effect count back those 93 and reach the number 57. Once again the measuring unit is unity. Subtraction is an analytic process, a taking a part from a whole. Children find subtraction rather more difficult than addition. It is somewhat more complex in that, whilst in addition the numbers are both or all similar—they are parts from which a whole is to be produced—in subtraction one number is a whole and the other a part.

Multiplication is a process developed from counting and from addition, but it is not the same as addition, although its answer may usually be found by continued addition. There is in multiplication the extra concept of ratio. Addition is the genesis of multiplication, for an aggregation found by addition is in reality so many times the unit unity. When the child learns to count in twos he is still nearer to performing the process of multiplication.

In multiplication, the *parts* of addition give place to *factors*. One of these factors denotes the unit of measure, the other the number of such units in the required answer. Thus in the sum $7d. \times 6$, the unit of measure is $7d.$, and the number of such units is 6. It is to be noted that the multiplicand $7d.$ is a unit of measure, and the multiplier is a pure number. Also, the unit of measure can itself be broken up into a number of less units. In this case, the less units are 7 times $1d.$ We could term this $1d.$ a primary unit, and the $7d.$ a secondary unit derived from it. In multiplication there is thus a primary unit, from which is derived a secondary unit, and the product is so many times this secondary unit. The multiplier is the ratio between the answer, the product, and the secondary unit, the multiplicand.

Multiplication, like addition, is a synthetic process, a building up of a whole by taking a part a number of times.

The fourth process, division, the inverse of multiplication, is a development of subtraction. It is continued subtraction, for the subtrahends of subtraction may be taken from the dividend of division a number of times, and the number of times this takes place to leave no remainder is the quotient of the division sum. Again, although division may be considered continued subtraction, there is in it the idea of ratio which does not exist in subtraction. There is no ratio between the minuend, the subtrahend, and the answer of the subtraction sum. There is ratio between the dividend, the divisor, and the quotient of the division sum. Therein lies the greater difficulty of division over subtraction, the separation into equal groups over the separation into unequal parts.

The process of division is used in what have been described as two types of sums, namely, (*a*) "measuring" or

"division," and (*b*) "sharing" or "partition." The two types can be illustrated in this way. "If I have 20*d*., to how many children can I give fourpence?" The statement to this sum will be 20*d*. ÷ 4*d*. = 5. That is a specimen of the "measuring" or "division" type. It has a concrete divisor, and the method of procedure in actual fact is to count out 4*d*., and 4*d*., until 20*d*. are exhausted. Then is counted the number of fourpences. "If I have 20*d*., what equal share can I give to each of 5 children?" The statement here is 20*d*. ÷ 5 = 4*d*. It is a specimen of the "sharing" or "partition" type. The divisor is abstract, and the procedure is to give each child one penny, then a second, then a third, then a fourth. The counting of each child's share gives the answer fourpence. Whether these two types should be considered to be different is a matter of opinion. The mode of working is the same in both cases. Certainly the second type has an added idea: that of finding a fraction of the whole, the fraction in the sum cited being one-fifth.

Although the treatment of vulgar fractions does not necessitate a process beyond the four processes discussed, it would be well to consider them now, following the final statement in the last paragraph. Vulgar fractions give children a great deal of trouble, and seem to be beyond the comprehension of many of them. That should not be so, if they (fractions) are treated rationally. Fractions are parts. But parts are essential ideas in all the processes of addition, subtraction, multiplication, and division. In addition we add parts to form a whole. In subtraction we take a part from a whole. So, too, in multiplication we multiply a part to produce a whole, and in division divide a whole to find a part. In all those processes the parts used are numbers. Fractions should likewise be treated as numbers. One-fifth is as much a number as is 5; 4 and 5 are parts making up 9 when added together; $\frac{1}{2}$ and $\frac{1}{4}$ and $\frac{1}{4}$ are parts making up 1 when added together. 4 and 5 are numbers. So are $\frac{1}{2}$ and $\frac{1}{4}$. In multiplying 4 by 5 to make 20, the ratio of 4 to 20 is expressed by 5. In one-fifth the ratio is already expressed. A fraction is thus a more highly developed expression than an integer. It combines both analysis and synthesis. In the statement "3/8 of a cake," the 8 is the primary unit of measurement and the 3 the number of such units. Thus there is more exactness in the notation of the vulgar fraction than in that of the integer.

If number is a measurement of quantity, even improper fractions should be treated as numbers. There is no need for endless discussion as to whether they are or are not fractions. Recognize them as numbers and discussion becomes futile. "$\frac{5}{4}$ of a penny" is as truly a number as is 5*d*. It signifies that the unit of measurement is $\frac{1}{4}$ of a penny, and that 5 of such units form the quantity under consideration. Most assuredly $\frac{5}{4}$ of a penny is a number. It is 5 farthings! Why not consider it as much a number when expressed as "$\frac{5}{4}$ of a penny" as when written "5 farthings"?

In trying to discover what things are, it is often elucidatory to discuss what they are not. Let us apply this test to the four processes to clarify further our knowledge of them. What are they not?

The little girl who said that in addi-

tion and multiplication you make numbers bigger, and in subtraction and division you make them smaller was wrong, entirely wrong.

Addition is not a means of making bigger, of increasing, and the scholar who thinks it is has no comprehension of it whatever. He may be able mechanically to add, but he will not understand what he does in the process. When we add 15 and 13 together we have 28 both at the start and at the finish of the sum. Why do the sum, then? It is because the new arrangement, the new grouping of 28 for the quantity 28 is much more readily comprehended than the separate groups of 15 and 13. Two tens and eight units are less complicated for the mind to take in than one ten and five units and one ten and three units. This is even more evident when we add a series of numbers, say 3 and 7 and 11 and 9. 30 is easier of comprehension than those four separate numbers.

Subtraction is not a means of diminishing. In taking 15 from 28, and finding 13 are left, the same quantities are in evidence throughout the whole of the process. We start with 28, and we finish with 28, rearranged as 15 and 13.

Multiplication, like addition, is not a means of making bigger. The savage of old found difficulty in counting. After he had learned to count he still could not manipulate his numbers. Even the business-man of the Middle Ages had to have his expert to calculate for him. Today we are not faced with those difficulties. Notation has been standardized, and it is of such simplicity that the child mind can grasp it. Suppose we wish to state that we have 3 boxes each containing 150 oranges. There are 150 and 150 and 150, but that is not our standard notation. 450 is. Once again it is to be pointed out that there is no increase in the number of oranges. There were 450 in 3 times 150, as much as in 450 itself. The quantity has not grown.

Division is not a means of diminishing a quantity. If we divide £40 among 4 employees and give them £10 each, the £40 is still in existence. It has simply been rearranged into 4 groups of £10. Even if we divide £5 equally among 10 junior employees and find instead of £5 we need 10 ten-shilling notes, we have done neither increasing nor diminishing. We have again rearranged, this time £5 into 10 half-pounds, but the total amount has undergone no change of size.

Having discussed so fully the meaning of number—that it is a method of measurement—and the calculations of number by the four processes of arithmetic used in the Primary School, we shall feel confident to inquire into the best modes of presenting those processes to the scholars of 7+ to 10+. The following chapters will deal with the various aspects and ways of such presentation, their comparative advantages and disadvantages, and their difficulties and the best ways of overcoming them.

CHAPTER SEVEN

PRE-PRIMARY WORK

BEFORE discussing the teaching of the several processes involved in the arithmetic scheme of the Junior Section of the Primary School, it would be of advantage to inquire into the work of the Infant School. The child of 7+ enters the Primary School Junior for his first year's work in Class I. The teacher of that class must be in a position to answer the questions, "What should my new scholars know of number work? Must I start at the very beginning of number appreciation, or can it be assumed that a certain amount is known?"

It should be that a great deal of work has been done by the child, but the teacher of the first year Junior work cannot presume that anything on which formal work can be based *is* known. The teacher would not be wise to go over matter already thoroughly assimilated—that would kill the children's interest at once—but it would be as unwise to attempt to build on a foundation which was non-existent.

Two necessary inquiries should be made. First, the teacher should become conversant with the syllabus and methods of the Infant Department from which the children have come. Although these children have probably entered a new phase of their school life in a new department, and they will be working in a somewhat new psychological atmosphere, it would not tend towards progress were old methods suddenly to be dropped. There should be no rift-valley cleavage in the development of the work. Rather should there be linkage and overlapping. Especially is this true of the backward child. To break away entirely from the methods he has known, and to introduce methods quite new, however excellent they may be, would only confound this child of slowly working brain.

In the second case, the teacher should test the new class. It is easy to presume knowledge, but it is not safe. I have had parents bring children to me for admission into my school, very proud that they had reached the standard of doing "money sums." Yet when I have placed before them a florin and a sixpence, they have not been able to tell me the difference in value between the two coins. They could, on paper, subtract 1*s*. 10*d*. from 9*s*. 6*d*. They knew the rules of such subtraction, but that was all they did know. Their work was mechanical: they knew not what they were doing. It is possible to teach even an animal to count!

First, then, the syllabus and the methods.

In a well-conducted Infants' School, the child's natural interest in number will be used and extended. If he is a normal child, he will have used numbers often and pleasurably before he attains the compulsory school-age of five. He will have experienced number

concretely, but his experiences, resulting from a love of activity, will be haphazard and without ulterior aim.

The first stage will be for the school to supply similar experiences, but motivated by purposeful planning. The child will join in singing number games, such as "Buckle my Shoe," "This old man," "Nuts and May" (counting the number in each team as it increases or decreases); he will play scoring games such as skittles, marble alley, spinning disc, fish pond, hopscotch; he will engage in living activities as shopping, travelling, cattle farming, arranging tea-parties, where it will be necessary to have a "pint" of milk and a "pound" of cake. The accessories for these activities will be collected or made in the handwork lessons. Much of the work will appear to be play, but it will be directed play.

When it is sensed that this type of number work no longer commands interest, the second stage is introduced. In this, concrete material and apparatus are used. Beans, sticks, shells, counters, bricks, beads, a bead frame, imitation coins will be utilized. Number patterns, systematized, will be introduced. Then will come the fact that : : is four. Later it will be shown that the number four can be represented by the symbol 4. Thus there will be connected, ::, four, and 4.

It is frequent in Infant Schools for the number patterns to be made from 1 to 10. This seems logical, since we use a decimal notation. But it must not be forgotten that 12 is a most important number in our system of measurement: 12 pence make a shilling, 12 inches make a foot, twice 12 hours make a day, 12 months make a year, 12 is a dozen, twice 12 sheets make a quire. Thus, as so much of our measurement is based on a duodecimal system, it must be advisable to give attention to the number 12.

Again, the symbol 10 includes that difficult "0." "0" is nothing, and children cannot understand "nothing." How often does the teacher of the seven- or eight-year-old child find him, when doing such a sum as $\begin{array}{r}170\\ -\ 83\\ \hline\end{array}$ saying "3" from "0" leaves "3"? It would be far better for the Infants' teacher, when introducing the fact of place values, i.e. of units and tens, to take the child past the number 10 and work on the grouping with the number 12.

As it is quite possible number patterns will have to be used for backward children in the first year Junior School class, it would be well for the teacher to note the pattern forms in use in the Infants' School. The patterns can be arranged in such a variety of ways, for example, 5 could be set out as—

It would be absurd to confound the children by using a new pattern because they had entered a new class.

The third and final stage Evelyn E. Kenwrick, in her *Number in the Nursery and Infant School* (Kegan Paul, 1937), describes as "practice work with individual occupations." The aims of this stage are (*a*) to collect the knowledge gained by experience and the use of concrete apparatus and to systematize it, (*b*) to emphasize the relation between numbers and combinations of numbers and the grouping of tens and

units, (*c*) so to memorize the addition and subtraction of numbers up to, say, 12, that the answers are automatic, (*d*) to teach the meaning of the symbols +, −, =, and maybe ×, (*e*) to ensure the acquaintance of the commonest parts of the measures of money, length, weight, and capacity, and some of the facts of time.

The children will probably do some more or less formal work, of which the following are specimen types. Placing a small numbered card on a strip as answer to a sum, $\boxed{2+6=\quad\boxed{8}}$; writing the answer to a sum on a card, $\boxed{3+4=\quad}$; filling in a number other than the final answer, $\boxed{5-\quad=2}$.

And secondly, testing the children.

It is a comparatively easy matter to assess the children's knowledge of mechanical processes. A series of simple addition and subtraction sums will suffice. The numbers of these sums should be from 1 to 9. The cipher 0 should not be used. It cannot be reiterated too often that SMALL CHILDREN DO NOT UNDERSTAND "0." The sums should be of the type $3+5=$, $4+7=$, $8+5=$, $6-1=$, $9-5=$. Care should be taken in setting these sums. In the addition the first number should not always be larger than the second. A study of the chapter on "Addition" will show that children find $5+9$ to be more difficult than $9+5$, $6+7$ than $7+6$, $2+5$ than $5+2$, and so on.

The testing of a real knowledge of number is not so easy. It is not to be expected that the child can think in the abstract. He will not know that the square of three is nine. But having taken two objects and two objects together he has formed a group of four objects. He has sense-perceived that fact. Has that objective exterior work become, shall we say, objective mentally? Does the figure 4 mean nothing more to the child than four objects? Or does it now mean to him 2 and 2, one more than 3, a group of four ones, one less than 5, two times 2? In other words, have processes been going on in the child's mind helping him to form some conception of 4?

The following series of tests is of a type that should give the teacher the information required.

TEST A. Call two children to the front of the class. Ask one to hold up some fingers. Tell the class to think of his thumb as one finger. Then ask, "How many fingers are held up?" Repeat with the second child. Tell the two children to put down their fingers. Then ask, "How many fingers together were held up?" It will be noticed that the addition is to be done mentally. The objects—the fingers—have for that purpose been dropped.

TEST B. Repeat the process, asking the two children to hold up different numbers of fingers. Then ask, "How many more fingers did this child hold up than this one?" Again mental working is expected.

TEST C. Ask one of the children to hold up some fingers again. Tell him, after the class has seen how many fingers were held up, to drop them. Ask, "How many fingers did he hold up?" Then state, "He held up '*x*' fingers. Just reckon another boy is standing by him doing the same, and a third boy standing next him also holding up '*x*' fingers. Three boys each holding up '*x*' fingers. How many fingers are they holding up altogether?" Elicit how the answers are

obtained, by counting, by continued addition, by multiplication.

TEST D. Write a "6" on the blackboard. Ask, "Can you tell me how I can make up six things?" The number 6 is suggested because of the number of ways in which it can be made up. Notice especially from how many children the only answer given is "count up six things," which signifies the taking of one thing at a time. If the children can give this answer only, they have not progressed far. They are still, as Shakespeare says in *Othello*, "countercasters."

TEST E. Write on the blackboard $4+3=$. Ask first, "What is the answer?" When the answer has been obtained, finish the statement on the blackboard. Then ask, "What does that mean? Can you make it into a story?" In other words, the children are required to show they know that $4+3=7$ is symbolic of some objective operation.

If the class can give satisfactory replies to the questions, they have passed the purely mechanical and the counting stage of number. There will be reason to believe that they have commenced to form concepts of number. If the answers are unsatisfactory, and the tests in mechanical addition and subtraction prove correctness of knowledge, then the teacher will know that the children have not passed the "objective" stage, and it must be continued. If the children fail in both tests, it will be ascertained that there is not base whatsoever on which to build.

I have had occasion to use these five tests, and from my notes I give the results from a class of new first-year Junior School children of somewhat under average ability.

TEST A. One boy held up five fingers and the other four. A large majority of the class gave "nine" as the answer. There was a deal of under-the-desk finger counting.

TEST B. One boy held up three fingers and the other five. The class gave a great variety of answers, thus proving their inability to subtract, when not using the written symbol, or having objects to hand.

TEST C. The boy held up two fingers, and the children were told that another boy stood by him holding up two fingers, and a third doing the same. Many children gave the correct answer. When asked how they found it, the majority said, "I counted on my fingers." Three answers were, "I thinked it," "I thought it," "I thinked it in my head." On probing the last answer it was discovered that the boy had done a mental multiplication sum. He had realized the connection between addition and multiplication.

TEST D. Most children gave the answers "three and three," "two threes," and "three twos." After further questioning, without giving a hint, one child offered the answer, "four and two," and immediately after another said, "two and four." There followed "five and one," but no child suggested "one and five," nor could it be obtained. Again there was evidence that children find greater difficulty in adding numbers when the first number is less than the second.

TEST E. This test proved too difficult for the children. The answer "7" was readily given. But not until many minutes had passed did the boy who had "thinked in his head" offer the suggestion that "four pence and three pence make seven pence." No further

answers were obtained until the question was asked, "Could you put oranges into the story?" Then came the statement "four oranges and three oranges make seven oranges." One or two other concrete statements were then suggested by the class, but the result on the whole was quite unsatisfactory. It was evident that mechanically the statement was understood, but symbolically it was not.

The summing-up was that the class had not passed the "objective" stage. The mechanical work—tested by a set of addition and subtraction sums on the lines suggested earlier in the chapter—proved generally satisfactory. In the addition test the percentage correct was 91·9, and in the subtraction 90·3.

It appeared that the teaching had been based on "one," that five was five ones, that seven was seven ones, that all numbers consisted of a number of ones. The children did not appreciate "three" as an entity; they were still, when wanting to go to "three," putting down the savage man's one, two, three pebbles.

If the teacher of that first-year Junior School class proceeded to harder mechanical work, successful correct answers would possibly be obtained, but as regards the appreciation of number values there would be none. The children throughout their school life would be machine arithmeticians. Much objective work, much analysis of number, that is, much basic work, would have to be done before that class of children became "thinkers in number."

Therefore, I repeat, the teacher of the first-year Junior School class must know what the children are supposed to have done, and what they actually have accomplished before the syllabus of the new year's work is attempted.

At this stage there should be on a special shelf attractive reading books about numbers—books with plenty of coloured pictures of objects that children can count, and little number stories, etc., such as *Making Friends with Numbers*, a reading book of numbers, by Haydn Perry (Newnes Educational Publishing Co. Ltd.).

CHAPTER EIGHT

THE PROCESS OF ADDITION

As addition is the simplest of the processes to children, it should be the first in which the use of object is dropped. Quite early children can think of $3+2$ without the aid of sense-perception, and it is faulty to continue objective teaching after it has become unnecessary.

Step 1. The first exercises in mechanical addition should be of the simple type:

$$3+1= \qquad 3+2= \qquad 4+3=$$
$$2+1= \qquad 4+2= \qquad 5+2=$$

These should be followed by such sums as:

$$5+3= \qquad 2+4= \qquad 5+3=$$
$$1+2= \qquad 6+2= \qquad 1+5=$$

Here is introduced a pair of numbers of which the first number is less than the second. The reason for this introduction in the second series of sums will be given later.

Next should be set exercises composed of the addition of three numbers, as:

$$2+1+1= \qquad 4+2+3=$$
$$3+1+2= \qquad 3+4+1=$$

Step 2. Following these, sums should be set to be added vertically:

$$\begin{array}{c} 5 \\ 3 \\ \hline \end{array} \qquad \begin{array}{c} 8 \\ 2 \\ \hline \end{array} \qquad \begin{array}{c} 4 \\ 1 \\ 7 \\ \hline \end{array} \qquad \begin{array}{c} 2 \\ 8 \\ 6 \\ \hline \end{array}$$

It must be decided at the outset whether children are to be taught to add vertically from the top number downwards, or from the bottom number upwards. Although the latter method has been more commonly used, much can be said in favour of the former.

(*a*) The numbers are written from the top downwards.

(*b*) In downward addition the final addition takes place just above the line of the answer; in upward addition the mind has to remember the answer while the eye runs down the column of figures just added. The sight of those figures may affect the writing of the answer.

(*c*) It is said that downward addition is more accurate than upward addition. Before that judgment can be accepted much testing will have to be done.

(*d*) If carrying figures are to be written, it is easy to place them at the top of the column, ready immediately for the next addition. But the same objection can be made to this carrying of the "carrying" figure to the top of the column as was made in carrying the answer from the top to the bottom of the column in upward addition.

It has to be decided also how soon children shall be taught to add numbers directly and not to make up tens. It is highly probable that in the Infants' School they have been taught in adding, say, 8 and 7, to make the 8 up to ten by taking 2 from the 7, then adding

Order of difficulty.	*Test.*	*Number of times wrong.*	*Order of difficulty.*	*Test.*	*Number of times wrong.*	*Order of difficulty.*	*Test.*	*Number of times wrong.*
1	8+7	16		7+5	8	69	0+4	4
	9+6	16		8+6	8		1+5	4
3	5+9	15		9+0	8		5+3	4
	6+7	15		2+0	8		3+1	4
	9+7	15		2+4	8		9+8	4
	7+8	15		6+1	8		5+7	4
7	6+9	14		3+2	8		2+7	4
	4+9	14		5+2	8		0+5	4
9	8+9	13	43	8+4	7		7+2	4
10	7+0	12		6+8	7		9+1	4
	8+8	12		6+2	7	79	9+3	3
	7+9	12		2+2	7		8+2	3
	9+4	12		3+8	7		6+5	3
	4+0	12		5+5	7		8+3	3
15	8+0	11	49	3+3	6		6+4	3
	9+5	11		1+9	6		0+6	3
	4+8	11		5+6	6		4+5	3
	4+7	11		2+8	6		1+2	3
19	3+0	10		5+4	6		4+3	3
	7+6	10		2+6	6		2+3	3
	2+5	10		3+5	6	89	6+3	2
	4+2	10		2+1	6		0+7	2
	3+7	10		0+8	6		0+3	2
24	8+5	9		0+2	6		3+9	2
	7+7	9		4+4	6		1+3	2
	5+0	9		0+0	6		7+3	2
	7+4	9	61	9+9	5	95	4+6	1
	1+0	9		2+9	5		1+1	1
	3+4	9		1+6	5		5+1	1
	6+6	9		1+7	5		7+1	1
	1+8	9		4+1	5		8+1	1
32	5+8	8		0+1	5	100	9+2	0
	6+0	8		3+6	5			
	0+9	8		1+4	5			

Digit.	*When first number.*	*When second number.*	*When both.*	*Total errors.*	*Place judged by total of errors.*
9	73	89	5	167	1
8	71	73	12	156	3
7	73	82	9	164	2
6	67	60	9	136	5
5	61	58	7	126	7
4	70	63	6	139	4
3	61	24	6	91	9
2	56	56	7	119	8
1	48	35	1	84	10
0	40	87	6	133	6

the five remaining to produce the total of 15. This is very laboured, and the sooner the child can say straight away eight and seven make fifteen the better.

This introduces us to the necessity for an addition table, so that in the addition of such as 3 and 2 children do not form the habit of counting 3 and then counting 2 more. In other words, the necessary formation of the conception of 3 as a whole and not as 3 separate ones will be accelerated by the mechanical recognition of $3+2=5$. For rapid mechanical work to be done the child must automatically know that 6 and 7 make 13. There must be no hesitation in stating the answer. For that result continual drill must be done, and the daily five minutes' mental period is the time in which to do it.

Using the numbers 1 to 9 and the cipher 0, it is possible to make, taking two of them at a time, 100 combinations. Some of these combinations prove of greater difficulty than others. They, of course, should be the ones most frequently practised. But which are they?

The 100 combinations were recently given to 250 children, of the age-range of 7+ to 11+. The test was made to discover which of the combinations the children themselves said were most difficult. The result is not conclusive, as only 250 children did the test: for the conclusion to be satisfactory several thousands of children need to be tested. However, the results even from 250 children show the trend of difficulty.

The combinations were not taken in order, but were mixed up in this way:

$4+1=$	$3+6=$	$3+5=$
$2+7=$	$6+9=$	$6+2=$
$6+8=$	$0+5=$	$8+0=$
$0+1=$	$2+6=$	$9+5=$

and so on. They were divided into two sets of 50 each, and the sets were done at different periods to avoid tedium.

The results will be seen on page 209.

On analysing this table it is found that the main sources of trouble are:

(*a*) In the addition of larger numbers; (*b*) in the addition of numbers where the first is smaller than the second, e.g. the comparative greater difficulty of 4+8 (order of difficulty 15) with 8+4 (order of difficulty 43), of 6+7 (order of difficulty 3) with 7+6 (order of difficulty 19); (*c*) where one of the components is zero, if zero follows a number; (*d*) where there are double figures, as 7+7.

It is impossible to account for the 100 per cent. correctness of 9+2. The lack of error was not due to its position in the test: it was 49th in the first list of 50, and was preceded by 1+3 and followed by 8+1.

A further analysis of the table is of value. It shows the total number of errors for each digit (see table at top of p. 210).

There appears to be greater difficulty with 9, 7, and 0 when placed as the second component, but 9, 8, and 7 give children generally the most trouble. It seems strange that 4 should appear to be more difficult than 6 or 5, and 2 more than 3.

The addition table should be compiled in this way:

0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	0	0	0	0
0	1	2	3	4	5	6	7	8	9

0	1	2	3	4	5	6	7	8	9
1	1	1	1	1	1	1	1	1	1
1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9
2	2	2	2	2	2	2	2	2	2
2	3	4	5	6	7	8	9	10	11

and so on. This will give the possible 100 combinations. The table given above, or a similar table compiled from the teacher's own testing, will demonstrate which combinations need most repetition. Some may be almost ignored.

STEP 3. The next sums will introduce to the class the addition of numbers composed of tens and units. Before they are presented, revision work testing the knowledge of the tens place and the units place needs to be given. Such as the following should be set:

14 is 1 ten and 4 units.
23 is . . . tens and . . . units.
3 tens and 2 units make 32.
5 tens and 8 units make . . .

The first sums composed of numbers with tens and units should require no carrying figures. They should be of the types:

18	22	16	10	23
21	34	3	24	20
		10	13	5
				10

The numbers in each sum should be analysed, the children noting, for instance in the first sum, that 18 is one ten and eight units, and the 21 two tens and one unit. Emphasis should be laid on "a units column and a tens column," and that all units must be placed in the right-hand column and all tens to the left of them. This especially should be noticed in the third sum, in which the second number is 3. The lesson might proceed in this way: "Why is the 3 under the 6? Why is it not placed under the 1 of 16? If it were placed there, what would its value really be? What would the 3 become?"

To press home this most important point, exercises should be set in converting horizontally written sums (having no carrying figures) into ver-

tical ones. Such as the following should be written on the blackboard for this conversion to be done:

$6+11+2=$ $\qquad$ $13+5+20=$

$4+23+11=$ $\qquad$ $31+7+10=$

When the sums have been totalled, the answers should be read by the children, first as complete numbers, then as separate tens and units. That is to say, if the answer is 29, a child should say, "The sum is 29; 29 is 2 tens and 9 units."

STEP 4. Next should come sums requiring a knowledge of the process of carrying. They will be of the type:

34	27	33
28	25	19

and then

12	17	21
18	12	17
26	37	39

Up to this point no real difficulty in addition should have been encountered. The carrying figure will give the first general trouble. The teacher might introduce the class to it in this way.

"In these sums we are going to meet something new, something called a carrying figure. In the first sum we have to add 34 to 28. In the units column are 8 and 4; 8 and 4 added together make 12. What shall we do with the 12? Now 12, you have learned, is made up of 1 ten and 2 units. Can we put the 1 ten under the units figures, that is, under the 8 and the 4? We can put the 2 there, for that is 2 units. What shall we do with the 1 ten? We have a tens column, with a 2 and a 3 in it. We will think of the 1 ten with the 2 tens and the 3 tens, and add them together to make 6 tens. Then our answer will be 62."

Concerning the carrying figure, opinions differ as to whether it should be left to the memory, or whether it should be written in some convenient place. It would be preferable to get children to depend on their memory. But if, in so doing, sums are constantly done incorrectly, it would be advisable in the first year to permit the use of a written carrying figure, to be placed in small character either at the top or at the bottom of the tens column.

It has been suggested that addition work showing carrying figures might be set out in the following way (reminding us of "Napier's rods"):

```
4275
2428
 139
1856
----
7578
112
----
8698
```

Four columns of figures are used here to show more clearly the method employed. The carrying figures are not added to the next column, but are set out in a different line. Writing the totals of each column in this way shows distinctly the units total to be 28, the tens to be 17, the hundreds to be 15. One benefit from this method is that errors can be readily discovered. However, it is not a method to be advocated: the written carrying-figure line is unessential, for memory training can obviate its use.

It may be necessary in the early stages to work the tens and units sums

objectively. Sticks, made into bundles of ten, and singles for units can be utilized. For the first sum $\begin{array}{r}34\\28\\\hline\end{array}$ the children would find $8+4=12$, and with their sticks discover in 12 one bundle of 10 and 2 singles. From that could be determined the placing of the singles in the answer, and the carrying of one ten to the tens column.

It might or might not be found of advantage, as a reminder of place value, to put "t" "u" above the columns, *thus:*

$$\begin{array}{cc} t & u \\ 3 & 4 \\ 2 & 8 \\ \hline \end{array}$$

It has been suggested that it is advantageous to set out the addition sum in ruled colums, thus:

t	*u*
1	7
2	5
4	2

as a sort of abacus, but using symbols in the stead of beads. But I am not sure if the use of "t u" at the head of the columns has not a bad reflex action, when children are doing money sums. *How frequently do they say "10 pence = 1 shilling," remembering that 10 units = 1 ten!* It might be that the non-use of "t u" at the top of the column, and the new use, the new experience, of using "*s d.*" would obviate the error. Statistics as to whether children using the "t u" are more frequent offenders than those not using the "t u" would be of great interest.

The use of ancillary helps, of carrying figures, of sticks, of headed columns, of ruled columns, will depend on the intelligence of the pupils. If they are not needed, they ought not to be used. If they are used, they should be discarded as speedily as possible. We are trying to teach the child to think in number, and number is abstract, therefore the more mental working there is the more shall we be attaining our object.

Children are often taught, when doing processes, to repeat parrot-like expressions. Those expressions should be reduced to a minimum. For example, in the sum

$$\begin{array}{r} 15 \\ 28 \\ 39 \\ 16 \\ \hline \end{array}$$

following the method of making up tens, the children will say, 6 and 4 from the 9 make 10, and the five from the nine 15, 15 and 5 from the 8 make 20, and three left from the eight 23; 23 and 5 make 28; put down 8 and carry 2.

This, simplified, will become 6 and *9 make 15; 15* and 8 make 23; 23 and 5 make 28; put down 8 and carry 2.

The final form will be 6, 15, 23, 28; put down 8 and carry 2.

If the addition tables are thoroughly *known, it will be possible to* get *quickly* to the final form. The child will know mentally and immediately that six and nine are 15, and (knowing automatically 5 and 8 are 13), eight 23, and five 28. This final form is undoubtedly the one producing the speediest results, and is a progressive step *to the abstraction* of "thinking in number."

Simultaneously with the setting down of addition sums in columns should go on horizontal working. It is of value

not only to do the normal separate forms, but also to combine the two ways in one sum, as:

$$\begin{array}{l} 7+2+5+9= \\ 4+9+3+7= \\ 6+9+8+3= \\ 7+5+6+9= \\ \overline{}\,+\,\overline{}\,+\,\overline{}\,+\,\overline{}\,= \end{array}$$

The value in this is that the child can readily check his own working.

From very early days children should be trained in this habit of checking. It is well to set the class the standard of having not one sum wrong in the whole of an exercise book. It should be pointed out that such a standard is attainable, and that the method is to check each sum as it is done.

Addition sums can be checked even though no other processes have been learned. The ways of such checking are three: (*a*) If the total has been found by downward addition, it should be re-found by upward addition. (*b*) If there are three numbers, x, y, and z, in the sum, the total of the three should be found. Then should be added two of them, x and y, x and z, or y and z, and the third number added to that total. (*c*) If there are four numbers, w, x, y, and z, the full total should be found. Then any two should be added, then the other two, and those two answers totalled.

The four steps outlined have covered the requirements of the first year's addition of simple number. Our scheme of work limited for the seven-year-olds addition to units and tens, that is, to totals less than 100.

ADDITION OF MONEY up to 10 shillings is also included in the first year's scheme.

The first step will be to get the class acquainted with the fractions of a penny. There is no doubt children get troubled with these fractions.

STEP 1. The first step should be to handle real or cardboard coins—farthings, halfpennies, and pennies. Specimens of them should be cut from coloured gummed paper and stuck in the exercise book (Fig. 7). Then various exercises should be done, again by cutting out coins and sticking them in the children's books (Fig. 8). (To save space, the coins have been made comparatively smaller than the real ones.) Practice in the use of the fractions must be given by writing a series such as $\frac{1}{4}d.$, $\frac{1}{2}d.$, $\frac{3}{4}d.$, $1\frac{1}{4}d.$, $1\frac{1}{2}d.$, $1\frac{3}{4}d.$, $2d.$, $2\frac{1}{4}d.$ These should be read. Then questions should be asked as to their meaning, the answers being written by children on the blackboard. The lesson might proceed, "How do you write two farthings? How do you write a halfpenny? How do you write one penny farthing? What do six

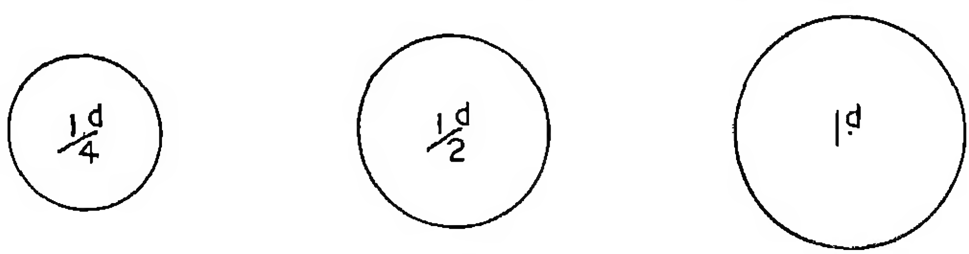


Fig. 7.

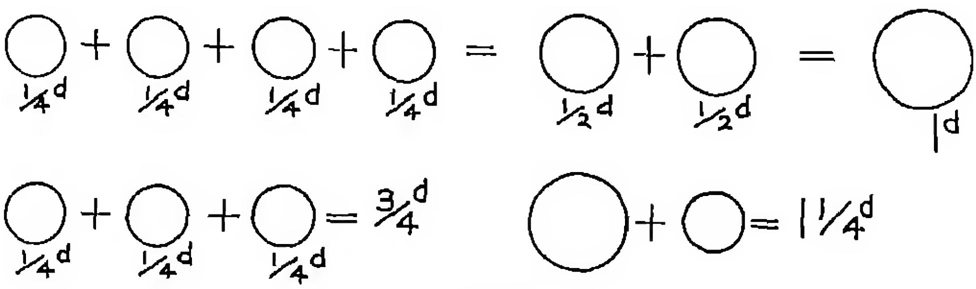


Fig 8.

farthings equal—how do you write what six farthings are worth?"

Of the symbols for farthings, children seem least to understand the writing of $\frac{3}{4}d$. During the courses of the first lessons of addition of money children should be asked repeatedly to write this symbol on the blackboard. They should have no chance of not understanding it. (It would not be wise at this stage to suggest it is a fraction — $\frac{3}{4}$ —of a penny. The seven-year-old will be able to memorize the symbol, but the concept of a fraction will be beyond him.)

STEP 2. Very easy sums should be set in the *addition* of pence and farthings, such as:

$\frac{1}{4}d. + \frac{1}{4}d. =$ $\quad \frac{1}{4}d. + \frac{3}{4}d. =$ $\quad \frac{3}{4}d. + \frac{3}{4}d. =$
$1d. + \frac{1}{4}d. =$ $\quad 1\frac{1}{2}d. + \frac{1}{4}d. =$ $\quad 2\frac{1}{2}d. + \frac{1}{2}d. =$

When the sums have been written on the board, they should be read by individual children. The questions should be asked, "What is the answer to the first sum? How is the answer written? What is the answer to number two sum?" If an answer of four or more farthings is given, questioning should proceed, "If I gave you four farthings, what would you give me for them? Then instead of putting down four farthings in the answer, what might we put? In all our sums, to what shall we change four farthings?" During these questions and answers, the answers to the sums may be written on the board, but after the reading of them they should immediately be rubbed out. It is required that children understand the sums: it is not required that they merely memorize the answers.

There will follow the writing and reading of larger values such as: $5\frac{3}{4}d.$, $6\frac{1}{2}d.$, $7\frac{1}{4}d.$, $8\frac{3}{4}d.$, $9\frac{3}{4}d.$, $10\frac{1}{4}d.$ Then the values will be used in sums, the totals of which will tend towards 1 shilling.

$4\frac{1}{2}d. + 1\frac{1}{2}d. =$ $\quad 5\frac{3}{4}d. + 2\frac{1}{2}d. =$ $\quad 3\frac{3}{4}d. + 7\frac{1}{4}d. =$

STEP 3 Sums should now be set down vertically, as

d.	d.	d.	d	d.	d.
$2\frac{1}{4}$	$4\frac{1}{2}$	$6\frac{1}{4}$	$1\frac{3}{4}$	$3\frac{1}{2}$	$2\frac{3}{4}$
$2\frac{1}{2}$	$2\frac{3}{4}$	5	2	$4\frac{3}{4}$	$3\frac{3}{4}$
			$3\frac{1}{2}$	$3\frac{1}{2}$	$2\frac{3}{4}$

Carrying figures having already been experienced, there should be no need for a first step of vertical addition without carrying figures.

Although the class may have textbooks, it is advisable, when taking a new step, to place the sums on the

blackboard for full class oral work. In that way it will be known that each individual's attention is directed to the work in hand. The sums then having been placed on the board, the lesson should take the line, "In the first sum, what are the two amounts of money to be added? How many columns are there? What are they? Which column did we do first in our other addition sums? What is the total of the first column in the first sum? Can we put 3 farthings in the answer, or must we do something to them first? Why?" This series of questions will link up the method with that of addition of numbers. Such should always be the aim: to impress the fact that processes and facts of arithmetic are not isolated—they are all related.

Attention should then be given to the second sum. "What is the total of the first column? Can we put 5 farthings in the answer? Why not? You say it is 1 penny and 1 farthing, what shall we do with the 1 penny and the 1 farthing? What is now the total of the pence column?" If the answers are satisfactory, the work should now be done in the exercise books, without further questioning. Most children will be eager to attack the sums on their own.

There is a usage by some teachers of an "f" above the farthings column. That may or may not be sensible and valuable. If the "f" can be done without—and I see no reason for its use—it should be. Two points on the matter arise in the mind. Common habit does not use the "f," then why use it and then have to forget it? Secondly, one of the symbols in that line is not a symbol of farthings—it is one halfpenny, $\frac{1}{2}d.$ It may be called, for the purposes of addition, two farthings, but it still remains one halfpenny.

Step 4. This step will be the introduction of a shillings column in the sums. First it will be necessary to acquaint the children with shillings. They must handle actual and cardboard coins of that denomination. Then in their exercise books should be stuck coloured gummed paper replicas, as in Fig. 9. There should follow objective exercises in the changing of pence to shillings and of shillings to pence. Coloured gummed paper should again be utilized. (The coins could be cut out in the handwork lesson.) (Figs. 10 and 11.)

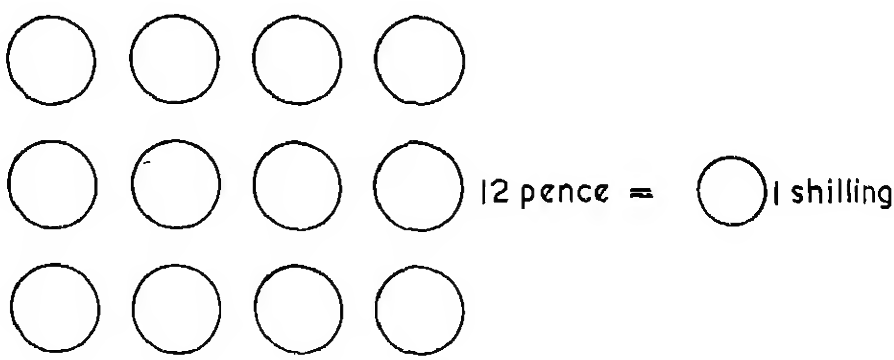


Fig. 9

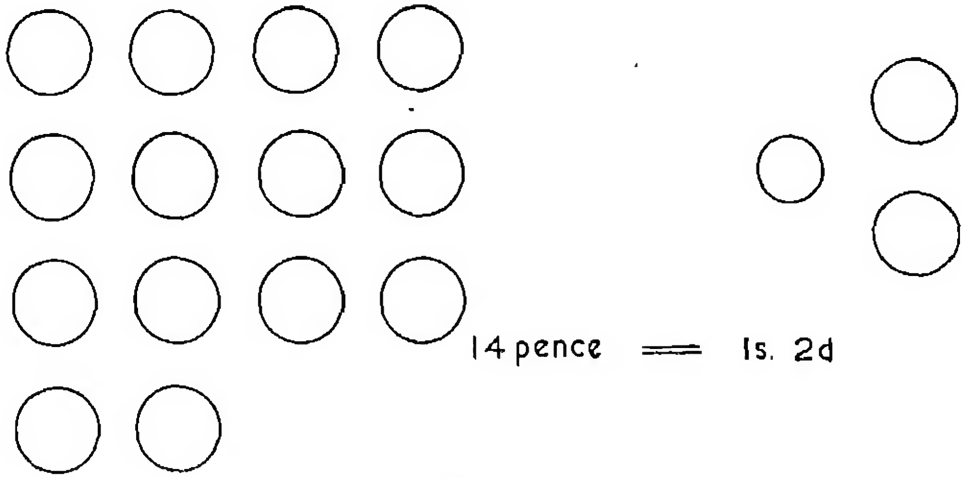


Fig. 10.

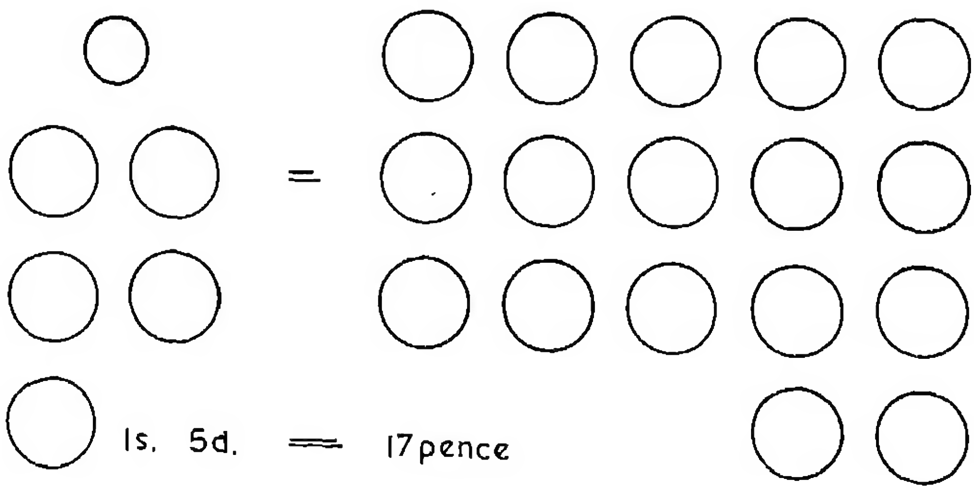


Fig. 11.

Children should be given the opportunity of making their own choice of representation up to a limit, say, of 24 pence or 2 shillings. Such work as this is not waste of time. It is most valuable preparatory work to the next step. There should be written work based on the objective work, as:

15*d*.= . . *s*. . . *d*.   1*s*. 7*d*.= . . *d*.
21*d*.= . . *s*. . . *d*.   1*s*. 11*d*.= . . *d*.

STEP 5 This step should be of sums with a shillings column. The work should be in two parts, with shillings as carrying figures only, then with shillings in the shillings column.

d.	*d.*	*d.*
$3\frac{1}{2}$	$5\frac{1}{4}$	7
$2\frac{3}{4}$	$6\frac{1}{2}$	$8\frac{3}{4}$
4	$1\frac{3}{4}$	$5\frac{1}{2}$
—	—	—

The items of the first sum should be read. The figures have been carefully chosen, as will be evident from the following questions: "With which column shall we start? What is the total of that column? What is to be done with the 5 farthings? What is the total of the pence column? What shall we do with the 10? Can we put it in the answer, for we couldn't in our tens and units sums? You say we can in this sum; why?" Thus will be emphasized the fact that 10 pence can be placed in the answer in the pence column. It should be further elicited that 11 pence can, also.

The second sum will provide the necessity for a shillings column. Having done the farthings column, and totalled the pence, the children will be faced with an answer of 13*d.* They should be asked, "Shall we put 13 pence in the answer? Can you think of anything 13 pence can be changed into? Then let us have a new column. What name shall we give to this new column? Now we will write our second sum with an 's' at the top of a new column."

The second part of this step will be to work sums of this type:

s.	*d.*	*s.*	*d.*	*s.*	*d.*
1	3	1	$4\frac{1}{2}$	2	7
	7	1	10	1	$8\frac{3}{4}$
1	8	2	$5\frac{1}{4}$	2	$4\frac{1}{2}$
—	—	—	—	—	—

There has now been covered the work in the process of addition in the scheme of the first year.

IN THE SECOND YEAR, the notation sums are extended to include hundreds. With the actual process there should be a minimum of difficulty, for, if children can carry from the units column to the tens column successfully, they can as easily carry from the tens column to the hundreds. But that is not enough. They should realize what they are doing, that is, working in a larger denomination. As ten units were taken to make one ten, now ten tens will be taken to make one hundred. Two ideas in arithmetic must be very strongly formed. They are (*a*) the standard and persistent grouping of tens, and (*b*) the value of place or position.

Therefore, with the purely mechanical working in hundreds, tens, and units should be done constantly such number drill as:

275 is . . . hundreds . . . tens . . . units.
603 is . . . hundreds . . . tens . . . units.
4 hundreds 2 tens 8 units make . . .
0 hundreds 9 tens 4 units make . . .
Write in tens from 455 to 495.
Write in hundreds from 863 to 463.
In the number 336, how many times greater is the first 3 than the second 3?
In the number 717, how much less is the second 7 than the first 7?

The second year's scheme also extends money sums from 10 shillings to £10. This necessitates the introduction of the pound.

STEP 1. Children should handle pound and ten-shilling notes. It will be useless to talk to them of sovereigns and half-sovereigns—they, apparently, are things of the past.

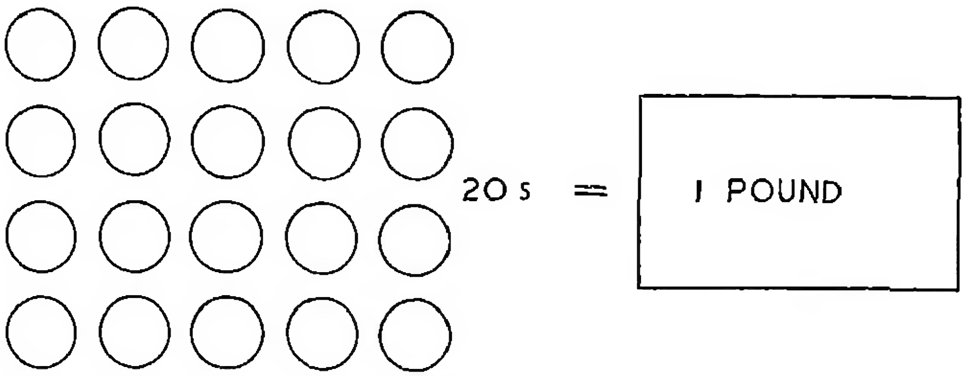


Fig. 12.

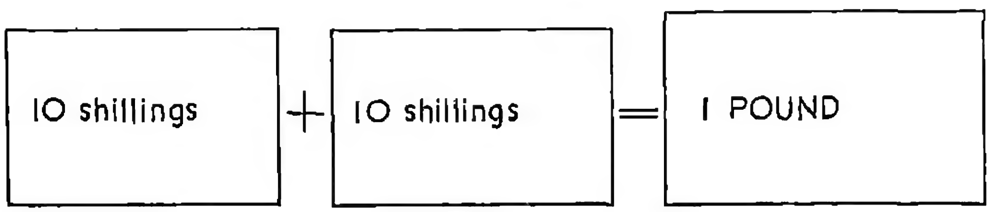


Fig. 13.

As in the first year, the children should cut out coins and stick them in their exercise books to show the relation between shillings and pounds. Notes can be represented by oblongs—a smaller one for ten shillings and a larger one for pounds (Figs. 12 and 13).

Then should be compiled a table of pounds and shillings (from 10*s.* to £10), by the children individually in their exercise books.

10*s.*= 10*s.*	110*s.*=£5 10*s.*
20*s.*=£1	120*s.*=£6
30*s.*=£1 10*s.*	130*s* =£6 10*s.*
40*s.*=£2	140*s.*=£7
50*s.*=£2 10*s.*	150*s.*=£7 10*s.*
60*s.*=£3	160*s.*=£8
70*s.*=£3 10*s.*	170*s.*=£8 10*s.*
80*s.*=£4	180*s.*=£9
90*s.*=£4 10*s.*	190*s* =£9 10*s.*
100*s.*=£5	200*s.*=£10

From that table children will be able to insert values in such sums as:

25*s.*=	98*s.*=	£2 14*s.*=	£8 9*s.*=
39*s.*=	154*s.*=	£5 11*s.*=	£9 13*s.*=

STEP 2. The next step will be to introduce the pound into vertical addition sums.

s.	*d.*	*s.*	*d.*	*s.*	*d.*
6	5	7	9	9	1½
9	10	8	3	11	6¼
1	7	6	7	8	9½

The first gives 17 shillings as a total. This is to show, as with pence, 10 or more can be put in the answer of the shillings By questioning, it should be discovered that any number to 19 can be placed there. The second sum will necessitate the making of a new column, the £ column.

STEP 3. Sums should next be set to include pounds in the pounds column.

£	s.	d.	£	s.	d.	£	s.	d.
2	13	4	1	9	$6\frac{1}{2}$	3	12	$7\frac{1}{2}$
1	7	11	2	14	$3\frac{3}{4}$	2	14	$9\frac{1}{4}$
2	8	8	2	6	$10\frac{1}{2}$	2	8	11

Children should not find difficulty in adding the shillings, although in the column there may be tens and units. The tens can never exceed in any line one ten. For example, in the third sum, with the 2 shillings to carry from the pence column, the addition will be 2, 10, 14, 16, and with the tens, 26, 36.

IN THE THIRD AND FOURTH YEARS' SCHEMES notation addition extends to thousands and tens of thousands, and money addition to £100 and £1,000 respectively. If the previous work has been done thoroughly and understood thoroughly, the children will be able to tackle these sums with the very slightest of guidance.

From the second year onwards, addition sums using various weights and measures are included in the schemes. Notice of them has not been made in this chapter, as they will be dealt with together later on.

Simultaneously with the purely mechanical will be done "word-sums" or problems. They, too, have not received attention. A separate chapter is necessary for their discussion, for they present several most important "problems."

CHAPTER NINE

THE PROCESS OF SUBTRACTION

THE process of subtraction should be taught next after its inverse, *the process of addition. Although,* as we have previously written, the psychologist would have us know that "the first procedure of the mind is analytic" and "synthesis is the last process of the mind in a complete process of thought," children—apparently quite illogically—find subtraction, which is analytic, more troublesome than addition, which is synthetic.

The introduction of the process of subtraction should not be withheld until after children have gained complete mastery over numbers of 4, 5, or more figures. It should be taught almost simultaneously with the addition process and, in the early stages, before the rigidly formal work is begun, addition and subtraction sums should be done together. Their relationship must be emphasized, their interdependence pressed home. No child should know that $3+2=5$ and $2+3=5$, without also knowing that $5-3=2$ and $5-2=3$. Mental work should be constantly given to show how, if two parts make a whole, the whole less than one of the parts will equal the other part. Such methods of sum setting as the following are very much worthwhile:

"Write these numbers, and in the *second column write the numbers to* make them

up to 10.		up to 20.		up to 30."	
3		11		18	
7		8		24	
0		15		10	
6		9		21	
9		4		17	

These sums should be done in stages, *with the other formal work.* There should be no hurry to make up to the bigger numbers, but eventually it will be possible in the first year to carry on to the making up to 90. Great value attaches to these sums. They link addition and subtraction, for they incorporate both processes. In the first sum, for instance, a child may start from 3 and count on his fingers to 10, finding he has counted 7 more. Therefore he will think "3 and 7 make 10" He may also think "10 take away 3 leaves 7. I must add 7 to 3 to make 10."

The objective work of the Infants' School will have been largely discarded as unnecessary when children at 7+ enter the Primary School. Many of them, however, when doing subtraction feel the need for objective help. They will use their fingers, and they certainly should not be stopped from doing so. As soon as they find themselves capable *of doing without* these exterior helps, they will voluntarily discard them. *They are never proud of using them:* more frequently is finger counting done

under the desk or behind the back than in the unhindered sight of teacher or fellow-pupil. "Conscience doth make cowards of us all." It is as if the finger-users felt they were breaking the law; therefore, I repeat, they will cease using those fingers as soon as a less "guilty" means of processing is comprehended by them.

Although it is essential to ensure that children are cognisant of the linkage between addition and subtraction, it must not be forgotten to point out their difference. Professor H. G. Wheat ably expresses this differentiation when he says that children should know that "addition means put things together or think things together" and "subtraction means take things away or think things away." But there must not be fixed the idea that the only way to state the process of subtraction is "from x take away y." Subtraction also includes the idea of comparison. It may be stated "how many more," "how much greater," "how many less," "how much smaller," "what is the difference between," "how much taller," "how much shorter," "how much nearer," "how much farther," "how much older," "how much younger," "what must be added to," "how many are left." Thus subtraction has two meanings—a taking away and a comparison. The former will be that given in sums in the early stages, the latter will be brought out in later sums. There will be further discussion on this meaning of "comparison" in the chapter on the consideration of the wording and working of "word-sums."

Let us now give thought to the steps to be taken in the teaching of the process. It is suggested that it would be wise to follow the adage "make haste slowly" and to consider with great care the constituent parts of every sum set. If that is done, difficulties should not be encountered.

STEP 1. The first formal subtraction sums should be of the form:

$4-1=$	$3-2=$	$2-1=$
$5-2=$	$6-3=$	$5-3=$

Similar sums should then be mixed up with those of addition, thus:

$3+1=$	$2+3=$	$2+1=$
$4-1=$	$5-3=$	$3-2=$
$4-3=$	$5-2=$	$3-1=$

To obtain speed in the subtraction of numbers 1 to 9—and these are the numbers that matter, for all greater numbers are composed of them—mental work could be done with a piece of apparatus made in the handwork lesson. It consists of three circles of cardboard, on two of which are written

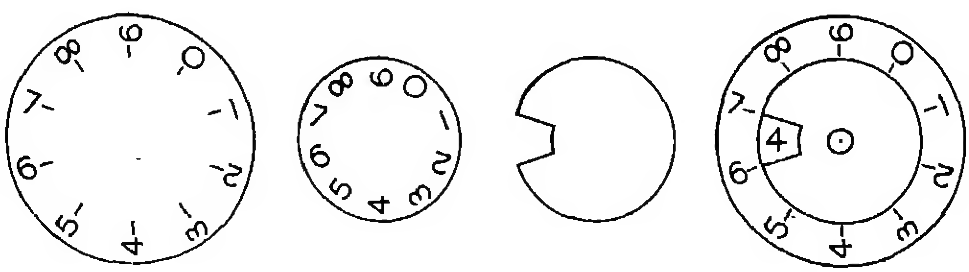


Fig. 14

the numbers. The circles are pivoted centrally, and by the movement of one of the circles sums can very quickly be set. A large model should be constructed for class use. A smaller model should be made for each child, and with it the child should be encouraged to arrange his own sums, and then to write them in his exercise book (Fig. 14).

Give the children many story-sums or *word-sums*: *John had 9 marbles and* lost 4. How many had he left? There were 10 birds in a tree; then 2 flew away. How many were left? Jane had 2 dolls, she wanted to have 6 dolls. How many more must she get? Tom had 9 apples, he ate 3. How many were left? Children can illustrate these word-sums. Give them exercises involving subtraction by inverse addition, thus $6-?=4$; $10-?=5$; $9-?=5$; $8-?=5$; $7-?=5$; $6-?=5$; $5-?=5$. Some children may be clever enough to manage the following equations, beginning with $4-1=3$; $?-?=3$; $?-?=3$, and so on. The last equation will be $10-7=3$. (Dull or backward children may work out equations with counters first.) Sometimes leave the child free to form any equations he likes, thus $?-?=?$ Successive subtractions form a useful exercise; for example, starting at 10 and subtracting 2 would give $10-2$, $8-2$, $6-2$, $4-2$, $2-2$.

It is as necessary to subtraction as to addition to construct tables of the 100 combinations resulting in answers 0 to 9. For a full benefit to be obtained from the tables they should be compiled in connection with the addition tables. Their form will be:

$$\begin{array}{rrrrrrrrrrr} & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ + & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \hline & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \end{array} \qquad \begin{array}{rrrrrrrrrrr} & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ - & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \hline & 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \end{array}$$

It should be pointed out that as "o" means "nothing," whether you add "o" to a number or take "o" from a number, the number is not altered: it is the answer.

$$\begin{array}{rrrrrrrrrr} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ + & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ \hline & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 \end{array} \qquad \begin{array}{rrrrrrrrrr} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ + & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\ \hline & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 \end{array}$$

$$\begin{array}{rrrrrrrrrr} & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 \\ - & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ \hline & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \end{array} \qquad \begin{array}{rrrrrrrrrr} & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 \\ - & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 & 2 \\ \hline & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \end{array}$$

And so on up to:

$$\begin{array}{rrrrrrrrrr} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ + & 8 & 8 & 8 & 8 & 8 & 8 & 8 & 8 & 8 \\ \hline & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 \end{array}$$

$$\begin{array}{rrrrrrrrrr} & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 \\ - & 8 & 8 & 8 & 8 & 8 & 8 & 8 & 8 & 8 \\ \hline & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \end{array}$$

$$\begin{array}{rrrrrrrrrr} & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \\ + & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 \\ \hline & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 \end{array}$$

$$\begin{array}{rrrrrrrrrr} & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 \\ - & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 \\ \hline & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 \end{array}$$

These combinations are fundamental, for whether 7 be taken from 15, or 17 from 25, or 87 from 95, 7 from 15 is the base of them all. As they are fundamental, it follows that they are of the utmost importance, and need always to be at the instant command of the scholar. It is experienced that children habitually find some of the combinations more difficult to memorize than others. A test given to 220 children who did the addition test recorded in the previous chapter resulted in this way:

Order of difficulty.	*Test.*	*Number of times wrong.*	*Order of difficulty.*	*Test.*	*Number of times wrong.*	*Order of difficulty.*	*Test.*	*Number of times wrong.*
1	17—8	32		12—3	12		6—5	9
2	14—8	28		10—3	12		6—2	9
3	15—9	26		9—8	12		4—0	9
4	16—7	24		9—0	12		3—0	9
	15—6	24		8—2	12	73	11—2	8
6	14—7	23		2—0	12		8—4	8
7	13—5	21		1—0	12		4—4	8
	12—7	21	42	12—8	11	76	10—7	7
9	16—9	19		10—4	11		9—9	7
	15—8	19		9—6	11		9—1	7
11	15—7	18		9—5	11		8—1	7
	13—9	18		9—4	11		7—0	7
	13—7	18		9—2	11		5—2	7
14	13—6	17		8—5	11		5—1	7
	7—7	17		6—6	11		4—3	7
16	16—8	16		6—0	11		4—2	7
	14—5	16	51	17—9	10	85	12—9	6
	12—5	16		10—6	10		10—9	6
	11—8	16		9—7	10		10—1	6
	11—4	16		8—6	10		8—8	6
	11—3	16		7—3	10		6—1	6
22	14—6	15		7—1	10		4—1	6
23	18—9	14		6—4	10		3—2	6
	14—9	14		5—5	10	92	7—6	5
	13—8	14		5—0	10		6—3	5
	11—9	14		3—3	10		5—4	5
	11—7	14		1—1	10		3—1	5
	7—4	14	62	11—6	9		2—1	5
29	10—8	13		11—5	9	97	10—5	4
	7—5	13		10—2	9		8—3	4
	2—2	13		9—3	9		5—3	4
32	13—4	12		8—7	9	100	0—0	0
	12—6	12		8—0	9			
	12—4	12		7—2	9			

It should again be pointed out that the evidence contained in the table is not completely conclusive, as the number tested was so limited.

Analyses of the tables gives the following results.

Minuend.	*Average number of errors.*	*Order of difficulty.*
18	14	7
17	21	2
16	19·6	3
15	21·7	1
14	19·2	4
13	16·6	5
12	12·8	8
11	15·2	6
10	8·6	12
9	10·1	10
8	8·4	13
7	10·5	9
6	8·7	11
5	7·1	16
4	7·4	15
3	7·5	14

Subtrahend.	*Number of errors.*	*Order of difficulty.*
9	134	3
8	167	1
7	161	2
6	124	4
5	120	5
4	107	6
3	89	9
2	91	7
1	69	10
0	91	7

Remainder.	*Number of errors.*	*Order of difficulty.*
9	160	1
8	133	4
7	150	2
6	146	3
5	102	6
4	117	5
3	90	9
2	98	7
1	76	10
0	92	8

These analyses show that the combinations oftenest wrong are those

(*a*) with a minuend of 14 or more;

(*b*) with a subtrahend of 7, 8, or 9;

(*c*) with a remainder of 6, 7, 8, or 9.

That is to say, the 7's, 8's, and 9's need more frequent repetition than the others.

STEP 2. Similar sums to those done horizontally will now be done vertically. The numbers should consist of units only, as

$$\begin{array}{r}7\\-3\\\hline\end{array}\qquad\begin{array}{r}4\\-1\\\hline\end{array}\qquad\begin{array}{r}8\\-2\\\hline\end{array}\qquad\begin{array}{r}9\\-5\\\end{array}$$

STEP 3. Then should follow sums consisting of tens and units, in each case with lesser tens and units in the subtrahend than in the minuend. Such are:

$$\begin{array}{r}25\\-13\\\hline\end{array}\qquad\begin{array}{r}37\\-14\\\hline\end{array}\qquad\begin{array}{r}49\\-32\\\hline\end{array}\qquad\begin{array}{r}83\\-50\\\hline\end{array}$$

Class attention to these sums would call for a lesson to proceed somewhat in this way "In sum one, have we to think of putting things together or of taking things away? How do you know? How many have we to take away? From how many? How many columns are there? What are they?

With which shall we start? In the units column, what shall we say? What is to be put in the answer? What is to be done in the tens column? What is to be put in the answer? Now read the answer. If I take 13 from 25, how many are left? If I take 12 from 25, how many are left? If I add 12 and 13 together, how many do they make?"

Procedure on this line should continue with several of the other sums. The children will be guided to think what they are doing, to understand what the process is. Far better this than the old-type parrot fashion, full class sing-song of "3 from 5 leaves 2, put down 2. 1 from 2 leaves 1, put down 1."

A question arises in connection with these sums. It appears to be quite trivial, but it is not. In the first sum $\begin{array}{r} 25 \\ -\underline{13} \end{array}$ should the children learn to think of "5 take away 3" or "take 3 from 5"? In other words, should children be led to consider the whole first and then the part to be taken away, or the part first and then the whole from which it is to be taken? I leave the point for your consideration.

STEP 4. Now follows the big step, the one in which a greater lower figure has to be taken from a lesser upper one, a step by which is done such a sum as $\begin{array}{r} 534 \\ -\underline{278} \end{array}$. A sum of larger numbers than would be attempted at this stage is given, so that the following discussion may be made more clear.

We have now to make a choice, for there are several methods of procedure. They have been in use for centuries. Each has its advocates and each its disputants. Let us consider the most used of these methods and their factors of advantage and disadvantage.

(1) *The Complementary Addition Method.*—If we take the example $\begin{array}{r} 534 \\ -\underline{278} \end{array}$, by this method we have to find a third line, an addition to 278 to make is up to 534. The words "take away" or "subtraction" do not enter into the sum at all. No thought of subtraction must be in the mind, although it is a subtraction sum. The process is "What must be added to 8 to make 4? That is not workable. Then what, must be added to 8 to make 14?" The answer being 6, six is put down. Next, "One of the 3 tens has clearly been used with the 4 to make 14. The working of the tens column will therefore be, what must be added to 7 to make 12?" The answer being 5, five is written. Then, "One of the 5 hundreds having been used with the tens figure, the working of the hundreds column will be, what must be added to 2 to make 4?" The answer 2 is written.

The advocates of this method support it because (*a*) it does away with the need for a subtraction table, (*b*) results are more speedy, as addition is easier than subtraction, and (*c*) it is the method used in everyday business. What of these points? Are they reasonable? The first is certainly true, but can the idea of subtraction be completely ignored? Can we eliminate entirely the use of the minus sign? If when required to subtract we always add, how can we get over to children what is meant by a sum like this one? "If 32 swallows are sitting on a telegraph wire and 18 fly away, how many are left?" Surely the idea of addition here would be absurd. There are birds

gone and birds remaining. Can one add their numbers together and still retain the idea that two very separate things have happened to them? Again, how as addition can this sum $\frac{7}{8}-\frac{5}{16}$ be written down? I am not disputing the advantage or otherwise of the "complementary addition" method; I am objecting to a premise that, even though the subtraction table be not necessary, subtraction can be discarded. The second point (*b*) may or may not be true. Much scientific testing would have to be done to prove its truth. The third point (*c*) is undoubtedly frequently true. When you offer the grocer a pound note to pay your bill of 15*s*. 9½*d*., he will count coins into your hand and say, "15*s*. 10*d*., 11*d*., 16*s*., 18*s*., £1." In other words, he gives you your change by adding. And when the coalman makes a delivery he calls to his colleague at the lorry, "2 more sacks, Bill," meaning that 2 added to the 8 sacks already emptied into the coal-cellar will complete the number ordered.

(2) *The Decomposition Method.*—This method has been in use in Italy, Spain, and India for many centuries, and is described in the oldest known English mathematics manuscript. To work out the sum $\begin{array}{r}534\\-278\\\hline\end{array}$ the "decomposition" method proceeds in this way: "8 from 4 cannot be done. Decompose the 3 tens into 2 tens and 1 ten and put the latter with the 4. 8 from 14 is 6. 7 from 2 cannot be done. Decompose the 5 hundreds into 4 hundreds and 1 hundred and put the latter with the 2. 7 from 12 is 5. 2 from 4 is 2. Answer: 256."

The protagonists of this method argue that it has the advantage of being logical and very easy to explain. In doing such sums as $14-8$, they say, a child has got into the habit of thought of subtracting units from a ten and units. Also, in considering place value the child has recognized that in the tens column a figure has a value ten times greater than the same figure in the units column. Therefore there is no hardship for the child to take, when necessary, a ten from the tens column in the minuend and convert it into ten units. The child has already often performed the operation: he has nothing new to learn: he simply applies existing knowledge. Investigation shows that the "decomposition" method does not give results quite as accurate and speedy as does the "equal additions" method, but the logicality of the method is worth the slight loss of correctness and speed. Such is the case for the decomposition method as stated by its upholders.

One visualizes cases in which difficulties arise in the use of this method. The memory will have much to exercise it in such a subtraction operation as:

£	s.	d.
100	0	0
− 76	13	8¼

If this method is the one used, as bigger and bigger numbers are involved, the terminology will become rather complicated. In a sum of five figures, say $\begin{array}{r}75{,}124\\-26{,}875\\\hline\end{array}$, it will have to be shown that one ten is decomposed from the tens column to place with the units, one hundred from the hundreds to place with the tens, one thousand from

the thousands to place with the hundreds, and one ten-thousand from the ten-thousands to place with the thousands. Or the teacher may wish to simplify the wording by stating that as that column—pointing to the thousands, maybe—is ten times the column to its right, one of the numbers from there will be changed into 10 of this column—pointing to the hundreds. Or, possibly, by the time such large numbers are set in a sum, the method will have become so understood and automatic that instruction will be quite unnecessary.

(3) *Equal Additions Method.*—This method, too, is a very ancient one, for it was employed by some of the earliest Hindu arithmeticians. It is based on the axiom that if equals are added to two differing numbers, their difference remains the same. In the case of the sum $\frac{534}{-278}$ the process by this method is, "8 from 4 cannot be done. Add a 10 to the 4. 8 from 14 leaves 6. Put 6 in the answer. As 10 has been added to the top line, a 10 must be added to the second line. To the top line 10 units are added: to the second line 1 ten. 7 and 1 are 8. 8 from 3 cannot be done. Add 10 tens to the 3 tens, making 13. 8 from 13 leaves 5. Put 5 in the answer. Ten tens have been added to the top line, one hundred must be added to the bottom line. 3 from 5 leaves 2. Answer: 256."

Those who support this method say (*a*) it is quite simple of explanation, (*b*) it has not to overcome the difficulty of the decomposition of "0" as in the sum $\frac{402}{-169}$, and (*c*) it produces results that are more accurate and speedy than those of other methods, and precedence should always be given in arithmetic to that which makes for accuracy.

One objection to this method is that it is unconnected with anything the child has ever experienced, in contradistinction to the "decomposition" method. But it is agreed that when the process of "equal additions" has been mastered, no difficulties are met in its usage. The same trouble with terminology occurs here at the outset as was outlined in the description of the "decomposition" method.

"The weight of evidence suggests that accurate subtraction is best attained by the method of equal additions," states the *Handbook of Suggestions for Teachers*. Personal experience enforces agreement.

The teaching of this method can be approached in one of two ways. The teacher can either simply state the process, and repeat it until it is known, or can explain what is done. Although it is best for children to understand explicitly what they are doing, it is not always possible for them to do so. Some facts they have to take on trust. Some explanations call on the complex process of reasoning, a process the undeveloped mind cannot perform.

If the teacher decides that explanation of the equal additions method should be given, the question must be asked, "Of what is the explanation to be?" It was stated above that the method is based on the axiom that equals added to unequals do not alter their difference. That is what has to be explained.

It could be dealt with in this way. "Henry, put 6 pencils in one box, and 4 in another. How many more are in one box than in the other? You say

2. Now put 2 more pencils in each box. How many more pencils are now in one box than in the other? You say 2 again. Put 3 more pencils in each box. Now how many more are in one box than the other? Still 2, you say. Do you know why? Perhaps not, so let us try again."

"Susan, put 5 books in a pile, and 2 books in a second pile. How much bigger is one pile than the other, or what is the difference between the number of books in the two piles? You say 3. Very good, now add 10 books to each pile. How many more now in one pile than the other? Still 3 you say. Why hasn't the difference changed?"

Similar experiments could be done with milk-bottles put into and left outside a crate, with sticks of chalk, rulers, and so on.

The children should be asked if one can give a reason why the difference does not change. The explanation may or may not be forthcoming. In any case, there will be dawning on the scholars' minds the idea of equal additions, and the teacher should proceed to the blackboard and write such a sum as $\begin{array}{r}7\\-2\\\hline\end{array}$.

Having obtained the answer 5, and written it, the teacher should proceed, "Now I am going to do with the sum what we have been doing with the pencils and rulers and other things. I am going to add 10 to the top line, and 10 to the bottom line $\begin{array}{r}17\\-12\\\hline\end{array}$.

How many are left now? 5, the same! Adding 10 to the top line and *10 to the bottom line hasn't made a bit* of difference to the answer, has it?"

Other sums of a similar character should then be done, as:

$$\begin{array}{r}8\\-4\\\hline 4\\\hline\end{array}\qquad\begin{array}{r}18\\-14\\\hline 4\\\hline\end{array}\qquad\qquad\begin{array}{r}9\\-6\\\hline 3\\\hline\end{array}\qquad\begin{array}{r}19\\-16\\\hline 3\end{array}$$

The above experiments and explanations will not all be done in one lesson. They may take two, three, or four consecutive lessons. Whatever time they take, the point will be arrived at when such a sum as $\begin{array}{r}52\\-19\\\hline\end{array}$ must be tackled.

Working on the same lines as in the preparatory lessons, the method will be, "9 from 2 cannot be done. I am going to do what we have done before. I shall add 10 to the top line, and make the 2 into 12. 9 from 12 leaves 3. 3 must go in the answer. Now I must add 10 to the bottom line, and I am going to add 1 ten to the 1 ten in the line and make it 2 tens. 2 from 5 leaves 3. Answer: 33."

The step has thus been reached for sums such as

$$\begin{array}{r}44\\-28\\\hline\end{array}\qquad\begin{array}{r}53\\-35\\\hline\end{array}\qquad\begin{array}{r}76\\-47\\\hline\end{array}\qquad\begin{array}{r}82\\-39\\\hline\end{array}\qquad\begin{array}{r}31\\-17\\\hline\end{array}$$

Horizontally stated sums should not be omitted. They are more difficult to the child than vertically stated ones, and if they are done correctly there can be no doubt that the child has learned the process. The sums should be of the type:

$$\begin{array}{ll}22-15= & \qquad 46-46=\\ 64-29= & \qquad 70-38=\end{array}$$

Children should again be reminded of the value of checking their work. Subtraction sums may be checked in two ways: (*a*) by using the inverse addition, i.e. by adding the two parts,

the subtrahend and the remainder, to make the whole, the minuend, or (*b*) by subtracting the part, the remainder, from the whole to obtain the other part, the subtrahend. It should be impressed on a child that he need never get a subtraction sum wrong. It can be double-checked. In doing this double-checking, the child will be strengthening the essential recognition of the close relationship between addition and subtraction.

The steps described, using numbers to 99, cover the first year's scheme of subtraction of pure number. Also included in the scheme is the subtraction of money to 10 shillings.

As children, for the purpose of addition, have already been introduced to the coins to be used, and to their value, work can proceed at once.

STEP 1. Simple sums of pence and farthings, written horizontally and vertically, without the requirement of "equal additions," should first be set.

$\frac{1}{2}d. - \frac{1}{4}d. =$ $\quad 1d. \; - \frac{1}{4}d. =$ $\quad 2\frac{3}{4}d. - 1\frac{1}{4}d. =$
$\frac{3}{4}d. - \frac{1}{2}d. =$ $\quad 1\frac{1}{2}d. - \frac{1}{4}d. =$ $\quad 3d. \; - 1d. \; =$

$$\begin{array}{cccc} d. & d. & d. & d. \\ 1\frac{3}{4} & 2\frac{1}{2} & 4 & 5\frac{3}{4} \\ -\;\frac{1}{4} & -1\frac{1}{4} & -1 & -2\frac{1}{2} \\ \hline \end{array}$$

A goodly number of such sums, up to $11\frac{3}{4}d.$, should be given, to allow for a growth of ease and confidence and happy acquaintanceship with the subtraction of pence and farthings. I would stress again and again the necessity to "make haste slowly." It is the height of absurdity to expect children to do for their first subtraction of money sum such an one as $\begin{array}{r} 11d. \\ -\;2\frac{3}{4}d. \\ \hline \end{array}$

One has to consider, not the very small minority of brilliant children, but the majority of average children. And with that consideration must go the truth that children have to find pleasure in their work. Unhappiness in lessons, especially in arithmetic, is the greatest deterrent to progress.

STEP 2. The second step, of course, will be the introduction of sums in which the value of the subtrahend figure is greater than that of the minuend. Sums such as these will have to be worked:

$$\begin{array}{cccc} d. & d. & d. & d. \\ 3\frac{1}{4} & 2\frac{1}{4} & 3\frac{1}{2} & 4 \\ -1\frac{1}{2} & -1\frac{3}{4} & -\;\frac{3}{4} & -2\frac{1}{2} \\ \hline \end{array}$$

For the first sum the procedure will be on these lines: "$\frac{1}{2}d.$ from $\frac{1}{4}d.$ cannot be done. What shall we do? No, we shall not add 10 to the top line. When Henry added pencils to his boxes, and when Susan added books to her piles, sometimes they added 2, sometimes 3, sometimes some other number. In this sum we are going to add 4 to the top line, because 4 farthings make 1 penny, and pennies are in the next column. (Or, we are going to add 1 penny and change it into 4 farthings.) 4 farthings and 1 farthing are 5. 2 from 5 leaves 3. We will put down 3 farthings. What did we add to the top line? What must we add to the bottom line? We will add 1 penny to 1 penny in that line. 2 pence from 3 pence is 1 penny. We put 1 penny in the answer."

It is of great advantage to children to know automatically that "$\frac{1}{2}d.$ from $\frac{1}{4}d.$ is $\frac{3}{4}d.$" That is to say, whenever they are confronted with "pence and $\frac{1}{4}d.$—pence and $\frac{1}{2}d.$," they do not have to go through the rigmarole of "$\frac{1}{2}d.$ from $\frac{1}{4}d.$ cannot be done. Add 1 penny. 1 penny and $\frac{1}{4}d.$ make 5 farthings. $\frac{1}{2}d.$ from 5 farthings is $\frac{3}{4}d.$" The possible combina-

tions of farthings where "equal addition" or "decomposition" is necessary are but three, namely, $\frac{1}{4}d. - \frac{1}{2}d.$, $\frac{1}{4}d. - \frac{3}{4}d.$, $\frac{1}{2} - \frac{3}{4}d.$ By much repetition in mental periods they can be completely memorized.

STEP 3. The third step will be the introduction of shillings into the sums. Children will have to see the reason for 12*d.* being added to the minuend and 1 shilling to the subtrahend, or for the decomposition of 1 shilling into 12 pence. It will be reasonable as a first part to this step to set sums of shillings and pence only, and in later ones to include the three columns of shillings, pence, and farthings.

What was said in the chapter on "Addition" with reference to the work in years two, three, and four, will be also true here.

If children have been thoroughly grounded in one of the methods of subtraction for numbers including tens and units, and for money consisting of shillings, pence, and farthings, they will have no difficulty in coping with sums of three, four, or five figures, and of money sums which include pounds.

It should also be stated, as it was in the last chapter, that the subtraction of weights and measures, and "word-sums," will be thoroughly discussed in later pages.

CHAPTER TEN

THE PROCESS OF MULTIPLICATION

WHAT shall be our approach to the teaching of the process of multiplication? Shall we tread the road of the old abacus computers and of the Romans with their cumbersome system of numeration, or shall we set out on an entirely new route? Multiplication is recognized and was first performed as continued addition. It is shortened addition, as we said in describing early efforts at devising arithmetical operations. Therefore, to introduce multiplication to children, shall we not do a series of examples of continued addition and then show how multiplication achieves the same result in a quicker manner?

If multiplication were nothing but a shortened form of addition, then veritably we should be on the right road. But it is more, much more, and in some respects it is distinct from addition.

There is intimate connection between the two processes in such facts as "three and three are six" and "two threes are six." But multiplication fails completely when an addition such as the following is proposed: $28+153+97+205+46$. That is continued or continuous addition, but it is not the special case in which multiplication is applicable. That brings us to one point of difference. Multiplication can take the place of addition in certain circumstances only. And what are those circumstances? They are when the numbers or groups or units to be added are all equal. And that means in a comparatively small number of cases, for if we take the number 5 and combine it with any of the nine numbers 1 to 9, in one case only are the two numbers equal, while in eight cases they are unequal.

It seems hardly wise, therefore, to start operations on multiplication by way of addition, to impress on the child's mind that multiplication is simply a shortened form of addition. Rather should this process be taught separately and stress put upon its two main essentials. To be able to use the process of multiplication there must be (*a*) equal numbers or groups, and (*b*) a number of these equal numbers or groups. The first essential (*a*) will form the multiplicand, the second (*b*) the multiplier. It is this idea of equality which needs the emphasis. In the sum, "There are 4 books on each desk, how many are on 9 desks?" it is the fact that there are 4 books, and not 3, and 5, and 6, and other numbers, on the desks, which makes it possible for the answer to be found by multiplication.

The sensible procedure will be to show the manner of the process of multiplication and when it can be used, then when the process is known, to relate it to the process of addition. Both are "putting-things-together

or thinking-things-together" processes. Both give more exact ideas concerning any number; for example, addition says of 12 that it is $9+3$ and $6+6$, and multiplication says it is two sixes or six twos. Thus the relationship is demonstrated, but the distinction should also be pointed out that addition cannot say 2 times 6 and multiplication cannot help when 8 has to be added to 3. Later the facts of factors and ratio as inherent in multiplication but not in addition will be given.

Time should not be wasted on frequent lengthy demonstrations of how multiplication can achieve in a short way the same result as addition. In the early stages it is necessary for pupils to recognize a difference between the two methods, or they will become muddled. Many relating examples will add to this muddling of ideas.

Tables

The key to multiplication is a knowledge of its tables. Without this knowledge the process is a closed door, or a very grinding, badly oiled one. All arithmetic teachers and theorists are agreed that the tables must be known, and known to such an extent that any particular item in them can be recalled from the memory instantly and without effort. But there is not agreement as to how or in what order they should be memorized.

In reference to the "how" memorized, one opinion is that they should not be committed to memory as entire tables, but that each line of a table should be learned independently of every other line. It is argued that the memorizing of the complete table causes children to recite the whole table when they require any one product in it. In contrast to this opinion, D. E. Smith, in his *The Teaching of Arithmetic*, states, "There is a great advantage in reciting all tables aloud, and even in chorus, since this leads to a tongue-and-ear memory that powerfully aids the eye memory when the pupil needs to recall a number fact." Personally, I shall be always grateful to my schoolmaster who made me not only say the tables aloud, but who composed a tune that I might sing them in chorus with the rest of the school. I certainly knew my tables!

Opinions also vary as to the order in which the tables should be known. One opinion is that the 10 times should be learned first. Another that the 7 times and the 11 times should be left until after the 12 times is known. A third is that 6 times should follow 5 times, and that 7, 8, and 9 times should certainly be the last to be memorized. My own opinion is that the 10 times does not require any learning—it is automatic—and that for the rest the natural order is the easiest. Children find very little difficulty with the two- and three-times tables. They readily count up by twos and threes, and the construction of the tables follows. If they know these tables, they are already acquainted with a part of the 4 times This is so all up the scale, and the higher one gets the more is known of the table from preceding ones. For example, if the tables have been learned in the order 2, 3, 4, and so on, when the 9 times is reached the only products children have not had previous introduction to are 4, namely, 9×9, 10×9, 11×9, and 12×9. Thus each table considerably helps succeeding ones.

However varied may be the opinions

on incidental points, all are agreed that

(*a*) tables must be known so that there may be a perfectly automatic recalling of any item in them;

(*b*) children should construct their own tables and know what they mean;

(*c*) tables should be taken slowly, and much "mental" practice in them should be given;

(*d*) children should know the commutation of factors, that is, as $7 \times 9 = 63$ so $9 \times 7 = 63$;

(*e*) tables are made easier if attention is paid to the pattern of them.

With regard to the last point, children should be guided to see that (*a*) in the 5 times table the units figure of the product is alternately 5 and 0; (*b*) that in the 2 times the pattern of the units figure is 2, 4, 6, 8, 0, in the 4 times it is 4, 8, 2, 6, 0, in the 6 times 6, 2, 8, 4, 0, in the 8 times 8, 6, 4, 2, 0, and in the 12 times 2, 4, 6, 8, 0, which is the same as the 2 times; (*c*) in the 9 times the units figure descends from 9 to 0 and the tens figure ascends from 1 to 9; (*d*) and in the 11 times, up to 9×11, the units figure, the tens figure, and the multiplier in any line are the same.

The Construction of Tables

As I have stated, I would start table work with the 2 times. My procedure would be in this fashion.

First, children should count up orally, individually, and collectively by 2's to 20, then backward by 2's from 20. They should then write what they have repeated. There should follow the imparting of the idea that the counting has placed the numbers in groups—in groups, that is, of 2. To impart this idea dots should be written on the board, thus:

. . . .

. . . .

The lesson should proceed: "How many dots are there? How many twos? How many groups of two? We can write that down in this way—

1 group of $2 = 2$	or	1 times $2 = 2$
2 groups of $2 = 4$		2 times $2 = 4$
3 groups of $2 = 6$		3 times $2 = 6$

or, to make it shorter, we may write—

$$1 \times 2 = 2$$
$$2 \times 2 = 4$$
$$3 \times 2 = 6$$

Now you write that down and see if you can go on until you have used up all the dots, that is, until you have reached $12 \times 2 = 24$."

The question here arises as to which of the two forms of table-writing is preferable, $1 \times 2 = 2$ or $2 \times 1 = 2$. The answer is that both forms should be written, for how valuable towards the full understanding of the law of the commutation of factors would such association be. For example, these two parts of the 9 times table

$5 \times 9 = 45$	$9 \times 5 = 45$
$6 \times 9 = 54$	$9 \times 6 = 54$
$7 \times 9 = 63$	$9 \times 7 = 63$

written side by side give visual help to an immeasurable extent. Yes, all tables should be written side by side in the two forms.

The climax of table-writing should be the construction of a comprehensive table of the pattern on p. 235.

	1	2	3	4	5	6	7	8	9	10	11	12
1	1	2	3	4	5	6	7	8	9	10	11	12
2	2	4	6	8	10	12	14	16	18	20	22	24
3	3	6	9	12	15	18	21	24	27	30	33	36
4	4	8	12	16	20	24	28	32	36	40	44	48
5	5	10	15	20	25	30	35	40	45	50	55	60
6	6	12	18	24	30	36	42	48	54	60	66	72
7	7	14	21	28	35	42	49	56	63	70	77	84
8	8	16	24	32	40	48	56	64	72	80	88	96
9	9	18	27	36	45	54	63	72	81	90	99	108
10	10	20	30	40	50	60	70	80	90	100	110	120
11	11	22	33	44	55	66	77	88	99	110	121	132
12	12	24	36	48	60	72	84	96	108	120	132	144

USING THE TABLE

To find the product of two numbers, one of them is found in the left-hand column; the horizontal line of that number is followed, until the column of the other number is reached; the number in the mutual square is the product.

The table can also be used for division. *The one factor given is found in the left-hand column, and its horizontal line is followed until the number to be divided is reached. Above that number, on the top line, is the other factor.*

The construction and memorizing of the simpler tables should not be left until addition and subtraction have been taught. With general number drill, they should go on simultaneously with instruction on the first two processes. They will prepare the way and will be ready for use for the formal multiplication work following that of subtraction.

STEP 1. The first sums may be called "table sums," and they should be of the type:

$9 \times 5 =$	$3 \times 3 =$	$11 \times 4 =$
$4 \times 6 =$	$12 \times 2 =$	$7 \times 5 =$

It should be shown that these can be written and worked in another form, namely, vertically, and examples as the following should be done.

$9 \times$	$3 \times$	$11 \times$	$4 \times$
5	3	4	6

It has been stated that multiplication sums such as these, and, of course, those that have larger numbers but which depend on these, cannot be satisfactorily done while tables are unknown. They may be done and the correct answer may be found, but if the result has been obtained only by laboured difficulty, the work must be classed as unsatisfactory. Such sums are acceptable only if the answer has been gained speedily.

As in addition and subtraction, the combinations of the multiplication of the digits 1 to 9 number 100. Some of the combinations are apparently more difficult to memorize than others; 200 children of the ages 8, 9, and 10, on being tested in a way similar to that in which they were tested with the addition and subtraction combinations, showed where they found the difficulties. The table is a synopsis of their work.

Order of difficulty.	*Test.*	*Total errors.*	*Order of difficulty.*	*Test.*	*Total errors.*	*Order of difficulty.*	*Test.*	*Total errors.*
1	0×9	66		7×7	19		2×3	8
	0×6	66	36	9×9	18	70	9×1	7
3	0×8	65		6×8	18		6×1	7
4	0×7	64		4×9	18		3×5	7
5	0×1	59	39	8×7	17		2×9	7
6	0×3	56		5×5	17	74	7×1	6
7	7×0	54	41	8×9	16		6×3	6
8	8×0	53		8×4	16		5×1	6
9	0×4	50		5×7	16		4×1	6
	0×2	50		3×9	16		2×8	6
11	3×0	49	45	7×6	15		2×6	6
12	9×0	48		7×4	15		1×8	6
	4×0	48	47	5×8	14	81	4×2	5
14	0×5	46	48	8×5	13		3×2	5
15	1×0	43	49	4×7	12		2×5	5
16	8×8	38		4×4	12		2×1	5
17	2×0	37		3×6	12		1×7	5
18	5×0	36		1×1	12		1×3	5
19	6×0	34	53	6×5	11	87	9×2	4
20	7×9	29		5×6	11		7×2	4
21	9×8	26		3×3	11		2×7	4
22	6×9	25	56	6×7	10		2×4	4
23	3×8	24		5×9	10		1×9	4
24	8×3	23		3×1	10		1×2	4
	6×6	23	59	7×3	9	93	1×6	3
	4×8	23		6×2	9		1×5	3
27	8×6	22		4×6	9		0×0	3
	7×5	22	62	9×5	8	96	5×4	2
29	9×4	21		8×2	8		5×2	2
30	9×6	20		8×1	8		4×3	2
	6×4	20		5×3	8		2×2	2
32	9×7	19		4×5	8	100	1×4	1
	9×3	19		3×7	8			
	7×8	19		3×4	8			

(The test does not include the 10, 11, and 12 times tables. The last two or three items of the 10 and 11 times and a large part of the 12 times appear often to be difficult of memorization.)

To simplify a summing-up of this table, let us designate the form of combinations as direct, indirect, and double. 7 × 5 is a direct combination, 5 × 7 an indirect, and 7 × 7 a double. For the purpose of the following analysis, in the combination 7 × 5, 7 is considered

to be the multiplier. The analysis of table shows the order of difficulty according to the number used. Combinations which include zero are omitted.

It will be seen that in the main there is very little difference whether the number is multiplier or multiplicand, but that the 7's and 3's show greater difficulty when multipliers and the 1's when multiplicand. As would be expected, the 2 times table, usually the first learned, is the best known, and the 8 and 9 times are the least well remembered. The zero combinations are the most fruitful of errors.

Digit.	*Average order of difficulty when* *Multiplier.*	*Multiplicand.*	*Average rank.*	*Order of difficulty.*
9	26	27	26·5	2
8	22	21	21·5	1
7	29	35	32	4
6	29	32	30·5	3
5	44	41	42·5	7
4	41	42	41·5	6
3	37	42	39·5	5
2	61	63	62	9
1	65	50	57·5	8

At the foot of the page is a second form of analysis.

It will be seen that (*a*) zero combinations are very poorly understood, (*b*) the bigger numbers give a deal of trouble, and (*c*) the combinations of 5's and 2's appear to be the best known.

STEP 1 (*continued*). It is agreed that the tables are the ABC of multiplication. In introducing the vertical method of writing the multiplication sum it would not be inadvisable, especially with children inclined to slowness or retardation, to construct the tables (or com-

Digit.	*Errors when* *Multiplier.*	*Multiplicand.*	*Both.*	*Total errors.*	*Order of difficulty.*
9	172	191	18	381	3
8	160	201	38	399	2
7	173	155	19	347	4
6	140	162	23	325	5
5	105	123	17	245	8
4	131	137	12	280	7
3	139	136	11	286	6
2	82	91	2	175	10
1	74	114	12	200	9
0	522	402	3	927	1

binations, if you will) in the vertical manner. If this be done, those troublesome zero combinations should be included. The omission of a zero table will thus be corrected.

0×	1×	2×	3×	4×	5×	6×	7×	8×	9×
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

0×	0×	0×	0×	0×	0×	0×	0×	0×	0×
0	1	2	3	4	5	6	7	8	9
0	0	0	0	0	0	0	0	0	0

1×	2×	3×	4×	5×	6×	7×	8×	9×
1	1	1	1	1	1	1	1	1
1	2	3	4	5	6	7	8	9

1×	1×	1×	1×	1×	1×	1×	1×	1×
1	2	3	4	5	6	7	8	9
1	2	3	4	5	6	7	8	9

and so on to

1×	2×	3×	4×	5×	6×	7×	8×	9×
9	9	9	9	9	9	9	9	9
9	18	27	36	45	54	63	72	81

9×	9×	9×	9×	9×	9×	9×	9×	9×
1	2	3	4	5	6	7	8	9
9	18	27	36	45	54	63	72	81

STEP 2. In the second step in formal multiplication attention should be given to the tens figure. As a preliminary, the first sums set should all have zero as the units figure. The type of sums should be:

20×	10×	30×	40×
4	6	3	2

As the numbers dealt with in written work in the first year do not exceed 99, a limited number of examples only can be given. The lesson might proceed in this way: "The sums you have been doing had units figures only. You started like that in your addition and subtraction sums, but soon you used tens figures also. Here are some multiplication sums, and they have both tens and units figures. How shall we do them? With which figure shall we start? Very well, if we do the units figure first, we do as we have done before. We say, 4 times 0 makes 0. What shall we do with the 0? Put it in the answer, but where? Yes, under the units figure. Can you suggest what to do next? Quite right, and we multiply the tens figure in exactly the same way as we did the units one. 4 times 2 are 8. And what are the 8? Tens, you say, then we put it where? What is the answer? What are 4 times 20?" The experience gained from practice with such sums will make the multiplication of the tens figure automatic, but, at the same time, fully understood. If it is

understood, then the multiplication of more highly placed figures will need very little, if any, attention. By the way, another value attaches to the sums of this step. The repetition of "something times zero" always equalling zero will impress that important point.

STEP 3 The next and final step will be to focus the attention on the carrying figure. Multiplication of both the units and the tens figures has been done. There remains but the one further operation—how to deal with the carrying figure. Sums of this type will be set:

13 ×	24 ×	18 ×
5	3	4

The work may be approached thus: "You have multiplied tens and units. Here are some sums of the same kind, but they have a carrying figure. Carrying figures came in your addition sums. From the units figures they were added to the tens figures. Let us see if in these multiplication sums there is any difference in what we do with them. What is the first answer? 15 you say, and that is quite right. Which part of 15 can we put in the answer? What is the 1, one what? We cannot put that in the answer. We haven't yet multiplied the tens figure, so we will remember we have 1 ten to carry. Now 5 times 1 make 5. What are the 5? Shall we put 5 in the answer? No, of course not, for we have another ten from the units column. So the tens together will be how many? Yes, 5 and 1 making 6. Six then goes in the answer in the tens column. How many are 5 times 13?" It will be necessary to point out the difference of method between addition and multiplication. In the latter the carrying figure is added *at the end* of the tens multiplication operation. In the former it is added at the beginning of the operation. This change should not lightly be passed over, for it may cause some confusion. It will require close attention, so that the incorrect addition of the carrying figure to the tens figure of the multiplicand may not be done, may not become a habit, and thus may not need to be eradicated.

No multiplication of money, or of any weights and measures, is included in the first year's scheme. We will therefore proceed to the work to be undertaken in the second year.

IN THE SECOND YEAR, the multiplication of the "hundreds" figure is introduced, using a multiplier not greater than 9, for to multiply by 10 would make necessary the use of the thousands figure.

Place value is of the highest importance in all multiplication operations. Therefore there should be at all times practice in number drill. Such exercises as the following should be of weekly occurrence.

Write in 10's from 185 to 235, from 321 to 271.

Write in 100's from 326 to 726, from 818 to 418.

In the first examples, working from smaller to larger and from larger to smaller numbers, the pupils will have constantly in mind the position of the tens figure. The choice of examples such as the first, which necessitates the change from one hundred to two hundred, is a happy one. It gives more practice and requires more thought than the writing in tens from, say, 313 to 363. The children's answer would have to be 185, 195, 205, and so on. The difficult point they find is the step from 195 to 205. In the second example set, the variation of the hundreds figure

will impress that position value on the pupil's mind.

Other forms of this number drill could be:

216. Hundreds figure . . . tens figure . . . units figure . . .

Pick out the tens figure from each: 427, 803, 695.

Little time need be spent on guiding the class into the correct method of multiplying three figures, and of carrying from the units to the tens, and from the tens to the hundreds. Only backward children will need help: those of average and more than average intelligence will be keen to accomplish by their own efforts.

This second year will see the introduction of the multiplication of money.

STEP 1. From the previous year there will be knowledge of many money relations, including the basic ones of 4 farthings $=1d.$, $12d.=1s.$ $20s.=£1$ will have been learned in this second year when addition sums were done. This knowledge should be enlarged by the construction and memorization of a pence table.

$12d.=1s.$	$40d.=3s.\ 4d.$
$20d.=1s.\ 8d.$	$48d.=4s.$
$24d.=2s.$	$50d.=4s.\ 2d.$
$30d.=2s.\ 6d.$	$60d.=5s.$
$36d.=3s.$	

and so on, up to $144d.=12s.$, and $200d.=16s.\ 8d.$ and $240d.=£1$. As will be seen, the table is constructed to give the number of pence in complete shillings, and the number of shillings and pence in "tens" of pence. If this table is known, it is a simple matter to convert any number of pence to shillings or shillings to pence.

STEP 2. The first multiplication of money sums should be of pence and farthings. Carrying figures need not be excluded—they already have been explained in addition of money and have been used in the multiplication of pure numbers. For the first step the product in the sum should not exceed $11\frac{3}{4}d.$ Many examples are available even with this limited answer, such as:

$d.$	$d.$	$d.$	$d.$
$2\frac{3}{4}\times$	$3\frac{1}{2}\times$	$1\frac{1}{2}\times$	$1\frac{1}{4}\times$
2	3	7	9

In doing the first sum orally the lesson might proceed: "What shall we do first? Very well, then, what are 2 times $\frac{3}{4}d.$? Shall I put 6 farthings in the answer? Why not? Good: they are $1\frac{1}{2}d.$ Shall I put anything in the answer? Then what shall I do with the $1d.$? What next shall we do? And 2 times 2 is 4. Shall I put 4 in the answer? Why not? Very well, you say I have to put $5d.$ What is the full answer? How much is 2 times $2\frac{3}{4}d.$?" Again, emphasis is needed that the $1d.$ carried is held up and remembered until the multiplication of the pence has been done.

STEP 3. Sums including shillings will be the next to be done. They should be of the following type, with products less than 20s.

$s.\ \ d.$	$s.\ \ d.$	$s.\ \ d.$
$3\ \ 5\frac{1}{4}\times$	$4\ \ 7\frac{3}{4}\times$	$2\ \ 4\frac{1}{2}\times$
3	4	8

The children should be required to recall what is the greatest number of farthings and pence that can be allowed in the answer. This is to counter the strongly formed habit of "carrying tens."

STEP 4. Sums will now be set to

include pounds. The earliest ones should have one-figure shillings only, of the type:

```
£  s.  d.            £  s.  d.
1  5   8½ ×          1  3  11¼ ×
       3                   7
```

The carrying from shillings to pounds should present little difficulty: the process has been done in addition. Again, the fact of 19*s.* being permitted in the answer should be elicited.

When two-figure shillings are included in the multiplicand it is well to change the method of carrying. Not only will this ease the work at present in hand, but it will be introductory to that when a two-figure multiplier has to be used. The new method should show how carrying figures are obtained.

```
£      s.      d.
1      13      11½ ×
                5
-----------------------
8      9       9½
-----------------------
5      65      55    4)10f.
3←     4←      2← —— 2d. ½
8  20)69   12)57
 └— £3 9s.  └— 4s. 9d.
```

The products are thus placed under a line left vacant for the answer. It is logical to put down the products before the carrying figure: that has been done in all previous multiplication sums. Therefore in the above sum the pence and farthings should be

```
d.                     d.
11½ ×       NOT        11½ ×
 5                      5
 ½                      ½
55    4)10             2←  4)10
 2← —— 2d. ½           55 └— 2d. ½
57                     57
```

THE SCHEME OF THE THIRD YEAR embraces pure number up to 9,999, and money sums up to £100. The number includes multiplication by two figures, but the multiplier in the money sums is still restricted to a number of the tables, that is, *from 2 to 12*.

Let us consider this multiplication sum: 186×47. The multiplication may be effected in two ways. One can multiply first by the units figure or first by the tens figure. The first method was once in vogue, but latterly it has been largely displaced by the second. It is said that multiplication by the tens figure first is preferable because (*a*) it is the essential mode of working approximations, (*b*) it will help when decimals are taught, and (*c*) it is less liable to error than the other method. Professors Wheat and Smith in their books demonstrate the old method of multiplying by the units figure first, and personally I prefer it: it logically follows all previous teaching. As to the reasons above, (*a*) and (*b*) cut no ice whatever. The third reason may or may not be true.

As the second method is now in greater use than the other, and as it is stated in the *Handbook of Suggestions for Teachers* that "the best method in long multiplication is to begin with the left-hand digit of the multiplier," that method will be the one described.

```
 186 ×
  47   = 40 + 7
 7440  = 40 times
 1302  =  7 times
 8742  = 47 times
```

It should be impressed upon children that sums in which there are many figures are more likely to be done correctly if the figures are set down in

exact columns. Neatness and extreme care are essential to accuracy.

In working the above sum as an example on the blackboard, the procedure might be: "In this sum we have to multiply 186 by 47. The multiplier is 47, and 47 is made of 4 tens and 7 units. We will multiply by the 4 tens first as if it were 4 units. We put the first figure of the answer under the 4, that is, under the tens figure. Why? Then we multiply by the units figure 7, and put the answer under the first answer we found, with the first figure under the 7. Why? And what shall we do with the two answers?"

At least for a time it would be of value for children to write at the side of the sum how many times the multiplicand each line represents.

THE WORK OF THE FOURTH YEAR includes compound multiplication of pure number to produce a product not greater than 99,999, and of money to £1,000.

It would be advisable to demonstrate an example of three-figure multiplication to the class, although no part of such a sum should raise one point of difficulty.

579 ×	
163	= 100 + 60 + 3
57900	= 100 times
34740	= 60 times
1737	= 3 times
94377	= 163 times

The placing of the first figure under the multiplying figure should be emphasized, and the reason for such a procedure given.

Compound multiplication of money will have to be shown to the class. Such a sum as the following should be done orally.

£	s.	d.	
23	14	$9\frac{3}{4}$ ×	
		17	
403	11	$9\frac{3}{4}$	
230	140	90	4)51f.
161	98	63	12d. $\frac{3}{4}$
12	13	12	
403	20)251	12)165	
	£12 11s.	13s. 9d.	

There are various other methods of finding the answer to this sum. A second method is that of the old-time practice style.

	£	s.	d.	
	17	0	0	= 17 times £1
		23		
	340	0	0	= 17 times £20
	51	0	0	= 17 times £3
10s. = $\frac{1}{2}$ of £1	8	10	0	= 17 times 10s.
4s. = $\frac{1}{5}$ of £1	3	8	0	= 17 times 4s.
6d. = $\frac{1}{8}$ of 4s.		8	6	= 17 times 6d.
3d. = $\frac{1}{2}$ of 6d.		4	3	= 17 times 3d.
$\frac{3}{4}$d. = $\frac{1}{4}$ of 3d.		1	$0\frac{3}{4}$	= 17 times $\frac{3}{4}$d.
	403	11	$9\frac{3}{4}$	= 17 times £23 11s. $9\frac{3}{4}$d.

A third manner of setting down is the following.

£	s.	d.	£	s.	d.	
23	14	$9\frac{3}{4}$ ×		1	$0\frac{3}{4}$	= 17 times $\frac{3}{4}$d.
		17		8	6	= 17 times 6d.
403	11	$9\frac{3}{4}$		4	3	= 17 times 3d.
				13	$9\frac{3}{4}$	
			8	10	0	= 17 times 10s.
			3	8	0	= 17 times 4s.
			12	11	$9\frac{3}{4}$	
			340	0	0	= 17 times £20
			51	0	0	= 17 times £3
			403	11	$9\frac{3}{4}$	= 17 times £23 11s. $9\frac{3}{4}$d.

A fourth method is to multiply each figure as it is reached.

	£	s.	d.
	23	14	9¾ ×
	17		
	230		
	161		
170s.	8	10	
68s.	3	8	
17 × 6d.		8	6
17 × 3d.		4	3
51f.		1	0¾
	403	11	9¾

To my mind the first method is the most sensible to teach. It is direct, it can be used for any multiplicand and any multiplier; it requires no thought as to how the "parts of £1" are to be found and related to other parts, and once taught and learned, the whole process is perfectly straightforward. Personally I would teach the one method, and that only.

A fifth method once much in use was by way of factors. The example done above would be set out in this manner.

£	s.	d.	
23	14	8¾ ×	
		8	
189	18	6	= 8 times
		2	
379	17	0	= 16 times
23	14	9¾	= 1 time
403	11	9¾	= 17 times

The method has little to commend it. With a number like 17 factorization is simple, but with a multiplier like 297 the time taken in finding factors is almost as long as that taken in finding the answer by the first method.

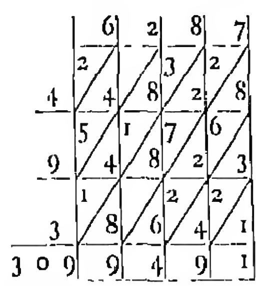
Very definitely I feel that these "fancy" methods create many opportunities for error, not created by the simple, straightforward method.

The checking of multiplication sums is by dividing the product by the multiplier. This can only be done when the process of division has been learned; when that has been done, checking should follow. (The checking could also be effected by an interchange of factors, that is, if 428 has been multiplied by 59, the same answer should be obtained by making 59 the multiplicand and 428 the multiplier. In the early stages that is not easy.)

To conclude this chapter, let us consider (*a*) the very old method of multiplication used by the Hindus, and (*b*) some special cases of multiplication.

A study of the Hindu method demonstrates how ingenious these very ancient mathematicians were. It would not be advisable to try to teach their method to small children, as it would appear to them to be complicated. It will be seen that the working was fairly sure to be accurate: there were no carrying figures. The difficulty of teaching lies in the fact that addition of the lines of the multiplication is not vertical but diagonal.

The Hindu worked the sum 6,287 × 493 in the following manner and setting. He placed 6,287 at the head of columns. The multiplier 493



6,287 × 493 = 3,099,491

he put at the left-hand side vertically, with the highest-placed figure, the

hundreds, at the top. Across the columns he drew diagonals. He commenced by multiplying by the 4, and said *4 times 6 make 24*. He put down the 24 in the way shown. In succession he multiplied 2 by 4, 8 by 4, 7 by 4, putting down the exact product, and using no carrying figures. Similarly, he multiplied by 9, and then by 3. It remained to add up the lines. This was done by adding all the figures between any two parallel diagonals. Thus the units figure was 1, the tens $4+2+3$, the hundreds $6+2+2+6+8$, and so on. In the additions it was necessary, of course, to carry figures. A remarkable centuries-old proof of mathematical genius!

Of special cases of multiplication the first to be considered is that in which there is a "o" in the multiplier. I am calling this a special case because "o" demands so much attention. The "combinations" test table shown earlier in this chapter proves the necessity for this emphasis to be put on the "o." The sign was invented not only to represent "nothing," but in writing to take the place of the empty column of the abacus. And that is the duty of the "o" which must be repeatedly pointed out. In the sum $6{,}582 \times 706$, the omission of the "o" line of multiplication will affect greatly other lines unless care is exercised. It should be impressed on the pupils that, although there is no necessity to write a line of zeros, the next line must be placed with due regard to position value.

Intelligent children should be guided to use their wits when working sums. In the fourth year—not earlier—it should be suggested to them that often by observation a quick method of obtaining an answer can be found. For example:

$$589 \times 99 = 589 \times 100 - 589 \times 1 = 58{,}900 - 589 = 58{,}311, \text{ or}$$

$$\begin{array}{rl} 589 \times & \\ 99 = & 100 - 1 \\ \hline 58{,}900 = & 100 \text{ times} \\ 589 = & 1 \text{ time} \\ \hline 58{,}311 = & 99 \text{ times} \\ \hline \end{array}$$

and 589×199, can be abbreviated to

$$\begin{array}{rl} 589 \times & \\ 199 = & 200 - 1 \\ \hline 117{,}800 = & 200 \text{ times} \\ 589 = & 1 \text{ time} \\ \hline 117{,}211 = & 199 \text{ times} \\ \hline \end{array}$$

Alert pupils will be intrigued by attempts to discover quick ways of doing other sums. For example, such as this might be shown them:

$$786 \times 243$$

In the multiplier 243 it will be noticed that $243 = 3 + 80 \times 3$. The working of the sum can therefore be

$$\begin{array}{rl} 786 \times & \\ 243 = & 3 + 80 \times 3 \\ \hline 2{,}358 = & 3 \text{ times} \\ 188{,}640 = & 80 \times 3 \text{ times} \\ \hline 190{,}998 = & 243 \text{ times} \\ \hline \end{array}$$

Such "playing with figures" should be introduced only to pupils who know the ordinary method and who fully and completely comprehend that most important factor of place or position value.

CHAPTER ELEVEN

THE PROCESS OF DIVISION

DIVISION is allied both to multiplication and subtraction. The parts of a division sum are a dividend, a divisor, a quotient, and maybe a remainder. It is the inverse of multiplication, for its divisor or quotient is the multiplier, and its dividend the product of the multiplication sum. Its relation to multiplication is closer than that to subtraction, for the dividend of division is the minuend of subtraction, but there the relationship breaks down. The subtrahend and remainder of the subtraction sum are *not allied to the divisor and quotient* of division except in one circumstance, and that is when a number of equal subtrahends compose the minuend or dividend, that is, when the subtrahend equals the divisor of the division sum. We thus arrive at a conclusion similar to the one formed in the discussion of multiplication. Division is shortened subtraction in one case only: the case when there is equality of numbers or group or units to be taken from a whole.

Children should not be introduced to division as a form of subtraction, even though in both one has to "take things away or think things away." The connection with multiplication is a much more common-sense starting-point, for if the pupils understand that equal numbers or groups are multiplied by a number of these equal numbers or groups, they should grasp the inverse, the process of finding from the whole the number *of* these equal groups, or the number *in* the equal groups. That is, if there is understanding of $5 \times 6 = 30$ and $6 \times 5 = 30$, then there should be comprehension of $30 \div 6 = 5$ and $30 \div 5 = 6$.

There is a reminder in the last paragraph that there are two phases of division, and these were explained in Chapter VI. They are operated in the same manner, but have different, although closely related, meanings. In the one is found the number of groups, *in the other the number in the groups*, constituting the whole. Various names have been given to these two meanings of the division sums, of one "measuring," "quotition," and "division," and of the other "sharing" and "partition." In the sums of the first type a concrete *quantity is measured into* a number of some other unit of the concrete quantity, as "How many 2-lb. bags of apples can be weighed from 22 lb. of apples?" In the second type a quantity is divided by an abstract number to give an answer of groups of that concrete quantity, as "If 11 bags are equally filled from 22 lb of apples, how many lb. are in each bag?"

The process of division is the most difficult of the four fundamental processes: teachers find that to be so in teaching, and children find it so in learning. A comparison of the tests of the simple combinations exemplifies the

fact. If the zero combinations are excluded—and they appear to be in a category by themselves—and the average number of errors per sum in each test is found (based on an equality of 200 children having done each test), the following result is obtained:

In Addition the average number of errors is 5·1.

In Subtraction the average number of errors is 10·9.

In Multiplication the average number of errors is 12·2.

In Division the average number of errors is 18.

(The table of result from the division test is given on a later page in this chapter.) The conclusion to be drawn from these figures is that the child himself says, "My average error is greatest when I do division sums, because of all my sums I find them the most difficult. I am prone to make more errors when dividing because I understand division least of all."

Division is a complex process. Not only is there in it the simple idea of "taking away," but it is complicated by the fact that the taking away is done in groups. A measured quantity has to be measured into smaller unit quantities, or a fraction of the measured quantity found. In multiplication a measured unit quantity is taken so many times. It is easy to conceive 2 lb. being taken eleven times. It is not so easy to do the inverse, to start with the product 22 lb. and break it up into a series of 2 lb. There are two measured units being used in the same operation: therein appears to be the complexity. By the way, in the very long history of computation development the sign ÷ is comparatively new. It would seem that the human mind did not intuitively arrive at the possibility of division, but found it only after much labour. It was not until 1659 that the sign was first used, and then by a Swiss, Johann Rahn. Through the translation of Rahn's book by Thomas Brancker it was introduced into England in 1668. (The + sign appeared in Widman's *Arithmetic* in 1489.)

It will be very necessary to work slowly and by most carefully graded steps when teaching this difficult fourth process. Even the form of question and statement must be thoroughly considered. What is the meaning of $12 \div 3 = 4$? In what terms shall we teach our pupils to interpret that statement? Mr. A. W. Siddons, in *The Teaching of Elementary Mathematics* (Cambridge U.P.), says, "Many children have a pernicious habit of saying '3 into 12' when dividing 12 by 3." "Many children" is surely a very mild statement of fact: do not *most* children interpret the meaning in that way? We are told that the reading should be "12 divided by 3 gives 4" or "divide 12 by 3 and the answer is 4." One teacher informed me that the child should be taught "Not '3 *into* 12' but '3 *out of* 12' is 4. Which of the formulæ is correct? You have a choice. Make your choice, and use it. Do not confuse the little ones by variations. Personally, I see no objection to the "3 into 12" reading. It is short; it answers the question, "How many threes in 12?", children who use it get their sums right, and thus appear to *understand it. And that is what* matters most. It is not the choice of formula that one has ultimately to consider, but the complete appreciation of that formula.

Tables

A knowledge of tables is as important to division as to multiplication. There cannot be speedy, accurate dividing done without such knowledge. All the facts of the division tables must be so known that the child can state them as instantly as a mechanical calculator works when a key is pressed down.

How shall the tables be taught? As with multiplication, I would teach them in the natural order of number, and very definitely they should be written in conjunction with the tables of multiplication. Each should be written in two ways, to start the children in the useful and important comprehension of the commutation of factors law in connection with division.

They should be set out in three columns, thus:

$1 \times 2 = 2$	$2 \div 1 = 2$	$2 \div 2 = 1$
$2 \times 2 = 4$	$4 \div 2 = 2$	$4 \div 2 = 2$
$3 \times 2 = 6$	$6 \div 3 = 2$	$6 \div 2 = 3$
$4 \times 2 = 8$	$8 \div 4 = 2$	$8 \div 2 = 4$
$5 \times 2 = 10$	$10 \div 5 = 2$	$10 \div 2 = 5$

and so on.

The Construction of the Tables

It has been stated earlier that in the Primary (Junior) School very little objective work relative to the four processes will need to be done. This statement may require adjustment in the case of division. The difficulty of the process may mean that it is not thoroughly understood by children leaving the Infants' School If that is so, to proceed without further appeal to eye and touch would vitally affect progress Much objective work—to a discussion of which we will return later—should be envisaged. After the handling and viewing of objects should be considered the construction of tables.

The building up of the "division by two" table could be done in this way. Take 8 counters and divide them into 2 equal groups. How many in a group? Take 10 marbles and divide them into 2 equal groups. How many in these groups? Then return to 2 pencils and divide them into 2 equal groups. It is suggested that the start be made with 8 and 10, and not with 2. The division of 2 by 2 is not easily understood, as the "combination test" table will later prove. Then go through the whole of the "division by two" table, using the same objects throughout, or a variety of objects, as 2 pencils, 4 matches, 6 sticks, 8 counters, 10 marbles, 12 sticks of chalk, 14 books, and so on. In each case divide into 2 equal groups. Then show children that what has been done can be written down:

2 divided into 2 groups is 1
4 divided into 2 groups is 2

and that this can be shortened to

2 divided by 2 is 1
4 divided by 2 is 2

Again, this can be much shortened by the use of a sign $\div$ to

$$2 \div 2 = 1$$
$$4 \div 2 = 2$$

Further tables should be constructed in a similar way, until it is ascertained that children understand the formation of the table and visual aid can be done without.

When the tables have all been constructed, children should be shown that for division as well as for multiplication they can use the combined table they built up from the multiplication tables.

Which of these combinations of figures do children find most difficult to memorize? The following is the division test set to about two hundred children of the ages 8, 9, and 10. I would repeat that the combinations were mixed up in a manner, to the adult mind, easy, less easy, difficult. In this test there are but 90 combinations, for divisions by 0—impossible to the child—were omitted. The test was set out in this way:

(1) 25÷5=	(4) 30÷6=
(2) 6÷1=	(5) 4÷4=
(3) 72÷9=	(6) 0÷8= etc.

I would also repeat that the results are not statistically conclusive. The test needs to be given to thousands instead of to hundreds of children.

Order of difficulty.	*Test.*	*Total errors.*	*Order of difficulty.*	*Test.*	*Total errors.*	*Order of difficulty.*	*Test.*	*Total errors.*
1	36÷4	38		28÷4	21	61	72÷8	12
2	54÷9	35		2÷1	21		36÷6	12
3	64÷8	32		0÷4	21		20÷4	12
	54÷6	32	34	56÷8	20		18÷6	12
5	27÷3	31		56÷7	20		12÷2	12
6	48÷6	30		42÷7	20	66	49÷7	11
7	81÷9	29		40÷8	20		8÷2	11
8	0÷3	28		8÷1	20		6÷3	11
9	24÷3	27		5÷5	20		1÷1	11
	18÷2	27		0÷6	20		6÷2	11
	3÷3	27	41	5÷1	18	71	30÷5	10
12	42÷6	26		3÷1	18		24÷6	10
	21÷3	26		0÷9	18		24÷4	10
	7÷7	26		0÷5	18		21÷7	10
	0÷1	26	45	36÷9	17		20÷5	10
16	63÷9	25		32÷8	17		16÷8	10
	32÷4	25		7÷1	17		12÷3	10
	8÷8	25		0÷8	17		6÷1	10
	4÷4	25	49	45÷9	16	79	12÷4	9
	4÷1	25		18÷3	16		4÷2	9
21	63÷7	24		9÷1	16	81	14÷2	8
	9÷9	24	52	40÷5	15	82	25÷5	7
	2÷2	24		35÷7	15		18÷9	7
24	45÷5	23		30÷6	15		16÷2	7
	0÷7	23		15÷3	15		8÷4	7
	0÷2	23	56	28÷7	14	86	16÷4	6
27	72÷9	22	57	27÷9	13		15÷5	6
	35÷5	22		24÷8	13		14÷7	6
	6÷6	22		10÷2	13		12÷6	6
30	48÷8	21		9÷3	13	90	10÷5	5

Analyses of the table give these results:

(*a*) When the Digit is the Divisor.

Divisor digit.	*Total errors.*	*Order of difficulty.*
9	206	1
8	187	3
7	169	7
6	185	4
5	136	9
4	174	6
3	204	2
2	145	8
1	182	5

(*b*) When the Digit is the Quotient.

Quotient digit.	*Total errors.*	*Order of difficulty.*
9	232	1
8	198	3
7	176	5
6	146	6
5	131	7
4	120	8
3	105	9
2	82	10
1	204	2
0	194	4

These synopses contain some remarkable pointers. Since working them out I have been in conversation with college lecturers and teachers of arithmetic in Primary Schools. Each has been astonished at what the child says is difficult. The fact is that we take too much for granted, and we grumble when we find in the arithmetic exercise book error after error made, we think, by reason of sheer carelessness. It is difficult to get into the child's mind, and the child finds it difficult to explain his difficulties. The easy way out for the teacher is to hope for the best, to grumble and to mark sums wrong. The hard way is to find the source of trouble and to provide a cure.

Consider the analyses.

In table (*a*), when the digit under consideration is the divisor, the child says he finds 9 most troublesome. That is expected. He goes on to say that 3 follows 9 in order of difficulty. Would you have said that? Would you not have said that 8 follows 9? The child says 8 *does* follow 9, but 3 intervenes. Why? According to the full table, the child says that $27 \div 3$ ranks fifth; $0 \div 3$, eighth; $24 \div 3$, ninth; $3 \div 3$, ninth; and $21 \div 3$, twelfth in the order of difficulty. In other words, he mixes answers up, for he is not sure of $27 \div 3$, $24 \div 3$, and $21 \div 3$. Again, would you have said that dividing by 1 would be in the slightest troublesome? The child says he does not find the manipulation of 1 at all easy: he prefers 4, and 7, and 2, and 5. Yes, he likes the 5. That to him seems to be the simplest of all the digits.

The second table (*b*) gives the more astonishing result that 1 as a quotient ranks second in difficulty order. With the exception of $1 \div 1$, no quotient of 1 appears of lower difficulty rank than thirty-fourth. What a revelation! The child says $3 \div 3$ ranks ninth, $7 \div 7$ twelfth, $8 \div 8$ sixteenth, and $4 \div 4$ sixteenth in difficulty order. Would you have prophesied such a result? Would you not have affirmed, without hesitation, that every child in the Primary School knew $3 \div 3$ gives an answer of 1?

From a study of the table and its analyses it is evident that 9's, 8's, 3's,

1's, and 0's require special consideration.

What is the lesson to be learnt from this discussion? Surely that for the teacher to be a successful educator he must study the working of the child-mind, and by some means or other must find the obstacles which hinder the even, smooth running of that mind. He must not measure the child's mental powers by the standard of his own mental development.

STEP 1. In the first year when division is introduced it must be ensured by objective work that the meaning of the process is understood. We are told that there are two meanings—the "measuring" meaning and the "sharing" meaning. It has to be determined which of the two shall take precedence. Some teachers choose examples first of the "sharing" type. Margaret Punnett in *The Groundwork of Arithmetic* (Longmans) prefers to commence with the "measuring" type and gives as her reasons that (*a*) when the division tables are introduced with those of multiplication, "measuring" is more evident than "sharing"; and (*b*) "sharing," carrying with it the notion of fractions, is more advanced than "measuring." On the other hand, opposed to these alternative choices, it is suggested that no distinction should be made. The child should be made to realize that taking things away by equal groups or finding the number of the equal groups is part and parcel of the same operation. It is division.

Acting on that last suggestion, the early exercises should be of the types of which the following are specimens.

1. Draw a line 4 inches long. Divide it into parts of 2 inches. How many parts?

2. Draw a line 4 inches long. Divide it into 2 equal parts. How long is each part?

3. Take 4 pencils. Give 4 each to some children. How many children have 4 pencils each?

4. Take 4 pencils. Divide them equally among 4 children. How many pencils will each have?

5. Take 30 beads. Thread them equally on 3 strings. How many beads on each string?

6. Divide a shilling into threepences. How many threepences?

7. Divide 12 pennies into 3 equal groups. How many pennies in a group?

After a considerable number of examples have been performed, this type of sum should follow orally.

1. How many twos in four?
2. How many fives in ten?
3. How many threes in fifteen?
4. What are four threes?
5. How many fours in twelve?
6. How many threes in twelve?

STEP 2. The next step will be to write down what has been experienced and answered. Sums of this type should be done.

$8 \div 2 =$ $\quad$ $22 \div 2 =$ $\quad$ $18 \div 3 =$

$14 \div 2 =$ $\quad$ $9 \div 3 =$ $\quad$ $4 \div 4 =$

It should then be shown that the sums can be written down in another way, thus:

$$\frac{8}{2} = \quad \frac{16}{2} = \quad \frac{21}{3} = \quad \frac{12}{4} =$$

Then the two methods should be associated, thus:

$$4 \div 4 = \quad 12 \div 2 = \quad 18 \div 3 = \quad 24 \div 2 =$$

$$\frac{4}{4} = \quad \frac{12}{2} = \quad \frac{18}{3} = \quad \frac{24}{2} =$$

STEP 3. After a number of sums have been set of the type above, children should be shown that there is a third style of writing the sums. The three methods should be compared.

$$8 \div 2 = 4 \qquad \frac{8}{4} = 4 \qquad 2\underline{)\,8}\atop\underline{\;4\;}$$

Thus has been reached the process of short division. Some theorists and teachers would omit short division and teach straightway the process of long division. They argue that long division is actually easier than short division, for all computations are written down. Other teachers would start with long division and teach short division later. That I feel is very much waste of time. If formal division is to start with the long method, then the short should not be taught at any time. It is my own experience and opinion that in the first year, at least, the short style should be adopted. Therefore the next step I would suggest would be sums of the short process definitely without a remainder.

$$2\underline{)\,6} \qquad 3\underline{)\,12} \qquad 3\underline{)\,21} \qquad 4\underline{)36}$$

The answers to all these sums can be obtained from a knowledge of, or by a recourse to, tables.

STEP 4. The next sums should be of a similar type, but should have a remainder. These should be introduced by such objective work as taking 7 sticks, dividing them into groups of 2's, and finding there is one remaining. The sum of such an operation should then be done.

2) 7
  3 and 1 remaining

The answer should *not* be written $3 + 1r$, for $3 + 1 = 4$, and there are not 4 groups of 2 in 7. The answer might be written 3 and 1r, or 3 *rem.* 1.

Care must be taken with the writing of the remainder when "word-sums" are done. If the sum is, "How many 2-pint jugs can I fill from 19 pints of water?" the working and answer should be

2) 19 pints
  9 jugs and 1 pint over.

If the sum is, "If 19 pints of water are poured into 9 equal jugs, how many pints does each jug hold?" the sum should read

9) 19 pints
  2 pints and 1 pint over

This is a "sharing" sum, and includes the idea of a fraction—one-ninth of nineteen. Really the 1 pint over can be poured into the jugs, so that the correct answer is $2\frac{1}{9}$ pints. It should not be 2 pints and $\frac{1}{9}$ over. The remainder as a fraction will not of course be considered in the first year. It will always be stated at this stage in the forms first suggested. The statement as a fraction remainder for a later year must be borne in mind.

STEP 5. There should follow sums in which there are tens and units in the answer. The first to be set should have no carrying figures.

$$2\underline{)\,28} \qquad 3\underline{)\,39} \qquad 4\underline{)\,49}$$

The lesson should proceed: "We have been doing sums in which we have been thinking of taking away in groups. In all the sums were numbers we knew in our tables. Now we shall have some that are not in the tables In the first sum we want to find out how many groups of 2 there are in 28. What shall we do? When we added or

subtracted or multiplied we started each time with what figure? In this sum we start the other way: we start with the tens figure. We say, 'How many 2's in 2?' And where do you think I put the answer? What ought we to do next? Yes, say how many 2's in the units figure. How many 2's in 8? And where shall I put the 4? Now tell me the answer. How many 2's are in 28?"

Included in this step should be sums in which there is a zero in the answer. Too much practice cannot be done to capture completely the elusive zero. Such sums should be:

4) 41   3) 32   5) 54

Several of them should be done on the blackboard with the whole class attending. Emphasis should be laid on the difference it makes to the answer if the "0" is incorrectly omitted.

STEP 6. The final step in the first-year work will be of sums in which there are remainders from the tens figures.

3) 58

In such a case as $58 \div 3$ the procedure could be, "What have we to find in this sum? How shall we start? How many 3's in 5? How many are over? What are the 2 that are over? We shall put those 2 tens with the 8 units. What are 2 tens and 8 units? Now we shall say how many 3's in 28? What shall we do with the 9? What shall we do with the remainder? What is the answer? How many groups of 3 are there in 58?"

Now that both multiplication and division have been done, the checking of these sums will be possible. Children should have become aware of the relationship between the two processes. The relationship will lead to the manner of checking: in multiplication obtaining the multiplicand by dividing the product by the multiplier or obtaining the multiplier by dividing the product by the multiplicand, and in division obtaining the dividend by multiplying the divisor by the quotient and adding in the remainder.

The scheme on which our work is based does not include the division of money in the first year.

IN THE SECOND YEAR, as hundreds are introduced, the process we have been considering will be carried forward to the division of three figures. But as the scheme includes only divisors not greater than 12, all the work of the year can be done by short division. The extension to a three-figure dividend, with the possibility of numbers remaining from both the hundreds and tens figures, should present no new point with which children could not cope. It might be advisable to work one or two examples with the class, especially of the type 3)127, where the divisor is not contained in the hundreds figure, and this figure has to be placed directly with the tens figure. Children should learn that there is no need to place a "0" in the answer under the hundreds figure. They should compare with that unneeded "0" the necessary one in such sums as

4) 416   or   5)652
   104   130 *rem.* 2.

Division of money up to £10 is a part of the second-year scheme.

STEP 1. The division of pence and farthings should be the first step. First, they should be without farthing remainders, as

$$\begin{array}{c} d. \\ 4\overline{)9} \end{array} \qquad \begin{array}{c} d. \\ 5\overline{)8\tfrac{3}{4}} \end{array}$$

The lesson could take this course: "What kind of sum have we to do? What have we to find? That is right: we have to divide 9*d.* into 4 equal parts, and to find how much is in each part. What shall we say first? And how many 4's are in 9? There are 2. What shall we do with the 2? Is there anything over? Correct, there is 1. What is the 1? What shall we do with it? We might put it as a remainder. Then our answer would be 2*d. rem.* 1*d.* Is there anything else we might do with this 1*d.* remainder? Change it into farthings! That is what we will do with it. Now we say how many 4's in 4 farthings? And we put the answer, $\frac{1}{4}$*d.*, down. What is the full answer. If we divide 9*d.* into 4 equal parts, how much is each part?"

The second sum should proceed on the same lines, the pupils being shown that 3*d.* over from the pence is changed to 12 farthings, the $\frac{3}{4}$*d.* are added, and then follows the question, "How many 5's are in 15 farthings?"

STEP 2. Shillings should next be introduced into the sums with the resultant necessity of changing remaining shillings into pence. For example, the sum might be

$$\begin{array}{cc} s. & d. \\ 6\overline{)14} & \overline{7\tfrac{1}{2}} \end{array}$$

The procedure of the lesson might be, "What does the sum ask us to find out? What kind of sum is it? What shall we say first? What do you think we do with the shillings which are over?" And so on.

STEP 3. This step sees the introduction of pounds into the division sum. It would be reasonable to omit farthings from the earliest examples of these sums. Included in the types set should be some where the pounds are less than *the divisor, where all the pounds,* that is, have to be changed to shillings.

THE THIRD-YEAR COURSE includes *numbers of four figures.* They entail division by numbers greater than 12.

STEP 1. Short division of numbers including thousands should first be be done.

STEP 2. They should be followed by division by numbers greater than 12, necessitating a knowledge of the "long" division process. The "long" process should be shown in comparison with the "short" process. They should be done side by side. There arises the question where the quotient should be written. At one time it was placed at the right in a line with the dividend. An improved technique altered its position and placed it above the dividend. This improvement shows exactly into which figure the division is being done, and there is a future benefit when division of decimals is in operation. It is a simple matter to decide where the decimal point shall be placed. The introduction to the "long" method should be in this way: the quotient of the "short" division sum is placed above the dividend to emphasize the connection between the two methods.

$$\begin{array}{r} 839 \text{ } \textit{rem.} \text{ } 1 \\ 7\overline{)5874} \end{array} \qquad\qquad \begin{array}{r} 839 \text{ } \textit{rem.} \text{ } 1 \\ 7\overline{)5874} \\ \underline{56} \\ 27 \\ \underline{21} \\ 64 \\ \underline{63} \\ 1 \end{array}$$

The two sums should be worked simultaneously step by step. As the working proceeds, children must be made to realize that the "long" method is exactly the same as the "short," except that in the "long" division all the mental work of the "short" method is written down.

Before proceeding to division by two-figure numbers, practice in "long" division by "table" numbers, that is, from 2 to 12, must be given. It is necessary for the children to become thoroughly acquainted with this new method before facing the difficulty of dividing by numbers requiring estimations for quotient figures. Sums such as these should be set:

"Do these sums first by the short way and then by the long way:

$8\overline{)5825} \qquad 6\overline{)7394} \qquad 11\overline{)9026}$."

When the process has become to a great extent automatic, sums with two-figure divisors will be demonstrated.

STEP 3. The primary obstacle will be the finding of the number of times the divisor figures are contained in the dividend figures, that is, if 5,139 is to be divided by 16, how many times 16 is contained in 51.

The procedure of the introductory lesson could be, "You have been dividing by numbers you know a great deal about. You have learned much about them in your tables. You can add them, subtract them, multiply by them, and divide by them. They are your friends, the 5's, the 7's, the 8's, the 10's. Now you must go a step farther and learn how to divide by a number that has tens and units, and is not a 'table' number. Look at this sum and think what it means:

$$20\overline{)6783}$$

What does it mean? What have we to do? We have to divide by 20, so first we must say, how many 20's in 67? Now 20 is 2 tens and 0 units, and 67 is 6 tens and 7 unts. Let us forget the units for a moment and think only of the tens. We will say how many 2's in 6? The answer being 3, we shall have to put that 3 down. Where shall we put it? Notice carefully that it is being put over the 7:

$$\begin{array}{r} 3 \\ 20\overline{)6783} \end{array}$$

Now we multiply 20 by 3, put the answer under 67 and subtract:

$$\begin{array}{r} 3 \\ 20\overline{)6783} \\ 60 \\ \hline 78 \end{array}$$

There are 7 over. What have we done before with the figure that is over? Yes, we have put it with the next figure. In this kind of sum we put the next figure with the over figure. Now we will say 2 into 7. It goes 3 again. Notice where we put the 3. Now we multiply and subtract once more.

$$\begin{array}{r} 33 \\ 20\overline{)6783} \\ 60 \\ \hline 78 \\ 60 \\ \hline 183 \end{array}$$

We still have one more division to do. We will say, how many 2's in 18? We put the answer 9 in our answer. Then we multiply 20 by 9 and subtract. We complete the answer, and the sum is finished.

$$\begin{array}{r} 339 \text{ rem. } 3 \\ 20\overline{)6783} \\ \underline{60} \\ 78 \\ \underline{60} \\ 183 \\ \underline{180} \\ 3 \end{array}$$

What is the answer? How many 20's are in 6,783? If you divide 6,783 by 20, what is the answer?"

Before the next stage is attempted, further sums, using exact tens as divisors, should be set, as—

$30\overline{)9518}$ $50\overline{)8219}$ $70\overline{)8386}$

STEP 4. *The final step is division by a number of two figures, the units figure not being zero.* The difficulty experienced here is due to the fact that when the quotient figure is found, the units figure as well as the tens figure of the divisor has to be multiplied by it. The resultant number may be greater than the corresponding number in the dividend.

It is often necessary to make a trial quotient answer.

Suppose the divisor is 38. It is very evident that finding the quotient number by dividing by 3 in the manner used in Step 3 will frequently prove incorrect. Some teachers suggest that in such a case, as the divisor 38 is more than half-way between 30 and 40, trial quotients should be found by dividing by 4 and not by 3. The objection to this is that two processes have to be learned, where one should suffice.

Let us demonstrate this step by using the sum $57\overline{)1,682}$. 57 will not go into 1 or 16 but 168; where will the first figure in the quotient come? How many 5's in 16? There are 3. We put 3 above the 8, multiply and subtract.

$$\begin{array}{r} 3 \\ 57\overline{)1682} \\ 171 \end{array}$$

"Something is wrong. You notice we cannot subtract. 171 is greater than 168. What do we learn from that? There are not three 57's in 168. We must try another answer. Shall we try 4? Why not? Yes, if 3 times 57 is greater than 168, 4 times will be greater still. What, then, shall we try? Yes, 2 will probably be correct.

$$\begin{array}{r} 2 \\ 57\overline{)1682} \\ \underline{114} \\ 542 \end{array}$$

"If, as we have done, we try an answer 3 and find it wrong, it will make our exercise books in a muddle. To save spoiling the careful work we do, we must make sure our quotient number is right. We can do that in one of two ways: we can either work out 3 times 57 in our head, or write it down. The better way is to work mentally, but if we have to write the trial working we should do it like this:

$$57\overline{)1682} \qquad \begin{array}{r} 3 \\ 171 \end{array} \qquad \begin{array}{r} 2 \\ 114 \end{array}$$

"We can in this way save our books from ugly alterations.

"We found above that 54 were over. As we did before, we put the 2 in the dividend by the side and have to find how many 57's in 542. Now we say, 5 into 54. How many 5's in 54? Can we put 10 in the answer? What is the greatest number we can each time put

in our answer? Then let us try 9, that is, 9 times 57.

	29 *rem.* 29	3	2
57)	1682	171	114
	114	9	
	542	513	
	513		
	29		

What is the answer? How many groups of 57 are there in 1682?"

If children cannot find the quotient figures mentally, they should be allowed to write neatly the trial figures by the side of the sum, as shown above. It should, however, be pointed out to them that with a little care and thought the sum *can* be worked mentally, and that that way is much to be preferred.

A second method of performing the long-division process is by using factors of the divisor. Thus, if 3,938 is to be divided by 75, the factors of 75 are found. They are 5, 5, and 3, and with them three short-division sums are done.

5) 3938		
5) 787 *rem.* 3 units		3
3) 157 *rem.* 2 groups of 5		+ 10
52 *rem.* 1 group of 25		+ 25 = 38 *rem.*

Answer: 52 *rem.* 38

The difficulties found in this method do not warrant the time taken to teach it. It is necessary first to find the factors of the divisor. That cannot always be done, for some numbers are prime. In the case, say, of 71 it is inevitable that long division is taught. Therefore, if the long method cannot be done without, why waste time teaching another and not less difficult method? In the second case, the varieties of remainder are a serious problem in themselves. It would not be simple to get children to follow, in the sum just done, explanations to show that the first remainder was of units only, the second of groups of 5, and the third of groups of 25. The remainders of division by factors are an excellent breeding-ground for errors.

Although in the third year division of money by numbers larger than 12 is not a part of the scheme, it would be of advantage to introduce the long method in such divisions. This is suggested (*a*) to keep in line with the new method of long division of pure numbers, and (*b*) to prepare for the necessary "long" process in the fourth year, when amounts of money will be divided by two or more figure divisors.

Little need be said here of the method. An example of the latest style of setting down, suggested, I believe, by Professor Nunn, will be sufficient to demonstrate its excellence.

	£	*s.*	*d.*	
	9	16	$10\frac{1}{4}$	
7)	68	17	$11\frac{3}{4}$	
	63	100	60	3
	5	117	71	4
	20	7	70	7
	100*s.*	47	1	7
		42	4	
		5	4*f.*	
		12		
		60*d.*		

THE FOURTH YEAR includes the division of larger numbers by larger divisors, and of money by two-figure numbers.

The work with pure number will follow directly from that of the third year and presents no new difficulty. There is a shortened form of "long"

division, called the Italian method, which might appeal to the brightest of the fourth-year pupils. The shortening is done by the omission of the multiplied line, thus:

```
       168 rem. 126
217) 36582
     1488
      1862
       126
```

This method should not be shown to any but the most mentally alert, for it requires a great deal of accurate memorization. It will be seen that the multiplication and subtraction are done in one line.

Over and over again reference has been made to the difficulty children experience in the use of zero. It must be impressed upon them that, although zero represents nothing, it does most important work. It fills a space in which there are no other figures, and keeps the other figures of a number in their proper position. It ensures that they have their exact place value. Simple examples requiring zero in the answer should be set frequently. Such are:

$$\frac{1{,}111}{11}= \qquad \frac{1{,}616}{8}= \qquad \frac{2{,}402}{2}= \qquad \frac{3{,}153}{3}=$$

Long division of money with divisors greater than 12 will follow naturally as a combination of the "long" division of money with "table" divisors taught in the third year, and the work in pure number of the present year. The process is the same as that exemplified above, and here there is no need to go into detailed explanations. The mode of working is:

	£	s.	d.	
	15	19	7½ rem. 30*f*. (7½*d*.)	
58)	926	18	10½	
	58	1120	432	2
	346	1138	442	144
	290	58	406	146
	56£	558	36*d*.	116
	20	522	4	30*f*.
	1120*s*.	36*s*.	144*f*.	
		12		
		432*d*.		

A second form of setting out the above sum is the following:

	£	s.	d.	
58)	926	18	10½	
	15	19	7½ rem.	30*f*.
	926	1138	442	146
	58	58	406	116
	346	558	36*d*.	30*f*.
	290	522		
	56£	36*s*.		

This is a shortened form, and the answer is placed below the dividend, instead of above it. The changing of the remainders of pounds, shillings, and pence is done mentally. In a complicated process like long division it is not desirable that anything which will make the process more difficult should be introduced. This method, if taught at all, must be used only by outstanding pupils.

A third method of doing the sum is by factors. The same objections raised against the factor method for pure number hold good when dealing with money. The above example has a divisor whose factors are 2 and 29. We cannot therefore use it as an example of the factor method Many other numbers are similarly incapable of simple factorization. Consider the numbers between 50 and 60. The factor

method cannot be used if the divisor is 51 (3×17), 52 (4×13), 53, 57 (3×19), 58 (2×29), and 59. Out of nine numbers three only can be satisfactorily factorized for this present purpose. What a useless method! What a waste of time teaching it!

The highest degree of accuracy and speed will be reached if straightforward methods are thoroughly taught, and adhered to. Those advocated in this chapter can be used whatever may be the divisor, that is, they are never failing. Why teach any others?

CHAPTER TWELVE

"WORD-SUMS" OR PROBLEMS

THERE are many circumstances in modern life which demand arithmetical calculation. When a new road is proposed, someone must survey the route of that road, someone must work out the amount of material to be carted to the site, he must ascertain the number of men required to carry out excavation and building up, and he must calculate how long should be permitted for the construction to take place. Similar situations arose centuries ago. The Roman conquerors of Britain also faced the problems of road-making, of the amount of material for the foundation and surfacing of their roads, of the numbers of slaves required for their construction, of the measuring and marking their lengths. Consequent upon the completion of the roads other problems arose, such as the time to be allowed for a legion of soldiers to traverse a section, of distances between strong points to ensure the efficient maintenance of military order, of the amount of grain to be stored for the feeding of garrisons stationed at the strong points, and so on. Simultaneously with the answering of these arithmetical life-problems on which the social welfare of the people depended, men produced, worked on, and argued upon, problems for the sheer love of the problems themselves.

There was no ulterior need for these problems. They served no commercial or political purpose. From them not one iota of benefit was obtained for the alleviation of poverty, no help did they give in food production, no assistance in the eradication of social evils, no contribution to the raising of the standard of life. They were problems compiled for problems' sake.

It is to be regretted that space forbids the recounting of many which appeared in most old arithmetic books. The following is one example, retold by Professor Wheat in his *The Psychology and Teaching of Arithmetic*: "A mouse is at the top of a tree that is 60 ft. high, and a cat is on the ground at its foot. The mouse descends $\frac{1}{2}$ of a foot each day and at night it turns back $\frac{1}{6}$ of a foot. The cat climbs 1 foot a day, and goes back $\frac{1}{4}$ of a foot every night. The tree grows $\frac{1}{4}$ of a foot between the cat and the mouse each day and it shrinks $\frac{1}{8}$ of a foot every night. In how many days will the cat reach the mouse, and how many ells has the tree grown in the meantime, and how far does the cat climb?" Such a problem gave to the ancients many hours of pleasurable disputation. (The interested reader for further examples of old problems should consult one of the books on the history of arithmetic.)

Ancient intellectual man loved problems: modern man enjoys them just as much. With the advance of education and a greater nation-wide training in logical thinking, wider and wider has

become the appeal of the problematic. The crossword, the quiz, the jig-saw puzzle, all claim in tens of thousands their fascinated disciples. What a number of magazines, and daily and weekly papers, cater for this love of that which puzzles. The modern writer, too, has appreciated this taste for the thought-provoking and has produced in shoals the problem story, the detective yarn. What a big percentage of B.B.C. programmes is engaged in a variety of forms of problem presentation!

Is this love of the problematic in the adult developed, or is it inherent? When crosswords were introduced they soon became what was spoken of as a craze. They are more than a craze, for such is but fleeting. The crossword puzzle has never lost its popularity. Its introduction supplied a want, a need for something over which pleasurably to ponder. Is this love inherent? Is it a part of the mental make-up of the child? Do the youthful enjoy a puzzle, a jig-saw, a quiz, a crossword? Do children turn with any show of delight to the puzzle page in their comic paper or magazine?

Experience says that undoubtedly the answer is an affirmative one. Then follows the question as to whether this propensity towards the problematic can be utilized in the classroom. Can it be turned to advantage by the teacher? And especially can it help in the teaching of arithmetic?

It has been stated earlier in this volume that one of the aims of the teaching of arithmetic is "to enable the pupil to apply mechanical skill intelligently, speedily, and accurately in the solution of everyday problems." Thus the child in after-school life will meet problems, but he likes problems, therefore there should be no objection from him when he is asked to do problems which will help him in his adult life. It seems strange that many teachers have told me that their pupils do not like problems, and that they cannot do them. It is our task in this chapter to find a reason for this apparent disagreement with previous statements we have made, and to discuss the matter of "word-sums" or problems generally.

Children begin their arithmetic by working concretely. Then we teach them mechanical processes, and lastly we place before them situations described in words and numbers. The progression is thus of three stages. Of the second section of the work, can it be said that it has any intrinsic value? Is it an end in itself? Or is it a means to an end? If a child knows how to multiply 759 by 38, of what value to the child is that knowledge? Will he enjoy life the more? Will he become a better and more valued citizen because of his possession of that knowledge? In the learning of the process there was a certain amount of mental drill, of mental discipline. But what was there beyond that? To be of value the newly found knowledge must be applied. It is that application which is our present concern.

The concrete work of the early stage centred around simple problems. In doing those problems, associated largely with the child's play life, he begins to appreciate the fact of number. When that appreciation is sufficiently strong, mechanical work can be undertaken and understood. Then can be tackled greater and more difficult problems.

The end, then, is not the mechanical, but the problem. Why not reverse the order and start with the problem?

That is the important thing. Begin with the problem, and as necessity arises teach the processes involved in the solution of the problem. Why not make the problem the be-all and end-all, and consider the process as purely incidental? Why not, for instance, start with the problem of finding how much concrete is required for a garden path, and then on discovering that a knowledge of area or volume is required to obtain the answer, introduce to the class what area and volume are? And why not leave the teaching of multiplication and division until it is found that those processes are a part of the problem just suggested? Again, why not start with the problem of making up packets of tea from a chest, and then teach the process of division that the answer to the problem may be found?

Such a procedure has been suggested. Is it reasonable? Would time be saved that way? Would children's interest be deepened? Do they like or are they bored by the mechanical? If they are listless over the mechanical, would the problematic save them from their boredom? Would the displacement of the mechanical by the problem result in the pupil's greater real knowledge of number?

Those who see many virtues in the mechanical object to an encroachment by the problem. They feel that the problem would take up time which would be more wisely spent in the practice of the mechanical. "Teach the mechanical," they say. "Introduce problems and you cut down the practice of the mechanical to a useless minimum, to a bare fraction of what it should be. The child will know his arithmetic better if in the Primary School he concentrates on the mechanical and leaves the problem for the Secondary School."

Which system is the better, the one which would give up the time-honoured practice of treating processes as topics and would proceed directly to the problem, or the other which would concentrate on the mechanical? Veritably, neither. They are both bad.

What says arithmetical history on the point? Did man, after he had learned to count, face the ever-increasing problems of the commercial world and attempt no mechanical way of solving his enforced numerical computations? He produced the sand-table and its pebbles, he produced the abacus and its beads, he produced "rods" for multiplication, and he produced a process of division. These he taught others that there might be to hand a ready means of solving the growing problems of the trader and of the business house.

Man was logical in his introduction of the mechanical, to be logical we must do the same. We shall teach the mechanical in order that the solution of the problem may be the easier.

When shall we begin the mechanical, and when the problem? In the previous four chapters the first part of the question has been fully discussed and answered. The best reply to the second half of the question is a consideration of the general forms in which a problem may be presented. Problems are either (*a*) mechanical sums clothed in words, or (*b*) queries with a setting in life situations. In actuality neither (*a*) nor (*b*) sums are problems. We do not set children problems. That is why, in an earlier chapter, objection was made to the use of the word "problem" and

the suggestion offered that "word-sum" be substituted for it. (So that the phraseology of this chapter is not misunderstood, the usual term "problem" is used—under protest!) We ask our pupils to do exercises illustrative of the processes taught. We know the answers to the exercises. We set nothing but what we know the children are capable of doing. Our tests are given to discover whether pupils can apply the processes they have learned, and whether they recognize that by means of these processes a solution can be found to various worded circumstances and situations.

The (*a*) sums should be set simultaneously with the teaching of mechanical processes. They will provide practice in the process, and show its connection with the concrete. The (*b*) sums will come later, for they will probably be involved and necessitate the use of a combination of processes. The first type may be exemplified by this first-year sum: "A school cap costs 3*s.* 6*d.* and a badge for it costs 10*d.* How much do cap and badge cost together?" Of the second type the following fourth-year sum is an example: "A silver cup cost 5 guineas. On it was inscribed 'Montem School Sports Trophy.' Each capital letter cost 4*d.*, and each small letter 3*d.* What was the total cost of the cup and the inscription?" Both these sums are addition of money; both are actual life situations. But the former differs very little from the normal mechanical addition sum, while the latter requires a series of additions. The amount of money involved places it in our scheme as a second-year sum, but its complicated statement makes it more fitting for a fourth- than for a second-year pupil. The *word-clothed mechanical* sum, then, will be the problem type for the first and second years, and it will be replaced gradually by the problem concerning wider experiences of life, requiring varied processes, in the later third and fourth years' work.

How shall we compose our problems? From what sources shall the material for them be drawn? Luckily for us the sources are inexhaustible, and the difficulty is to know what to leave out rather than to have to search to find material to put in. The following are some of the sources of our supply: (*a*) Problems may already be set for us in the class text-book we use. (*b*) They may be taken from children's games and puzzles. (*c*) They may be founded on facts of general knowledge. (*d*) They may concern the children's own life and that of those immediately around them. (*e*) They may be framed on a wider social life than that of the child's.

Shall we set sums from each and all of these sources? Are they all possible of use, or are some outside the range of the child's interest? Once again we meet that all-important "child's interest." It must have first consideration: without it useful work can never be done. Let us consider some specimen sums of these five types. (*a*) "Two pipes could fill a bath in 7 and 8 minutes respectively and a third could empty it in 12 minutes. They run together till one-third of the bath is full, and then the third pipe is shut off. What is the total time taken to fill the bath?" (*b*) "At a marble-alley game Mary scored 20, 8, and 16. Her father scored 4, 12, 20, and 2. Who won, Mary or her father?" (*c*) "If in 1937 Hutton scored 2,888 runs in 51 innings, how many runs on an average did he score in each

innings?" (*d*) "32 children in our class have a pencil each; 17 have broken points. How many pencils have good points?" (*e*) "Two towns are 180 miles apart. What is the cost of a return railway ticket between these two towns at $1\frac{1}{2}d.$ a mile?"

Having read examples of sums from each of the sources, let us consider again the question at the head of the previous paragraph. Shall we set sums from each and all of these sources? (*a*) If the text-book has been well and carefully written by one who is conversant with the psychology of the child, the problems it contains should be usable. But they may not all be exactly suited to the class using the text-book. It is the teacher's business to omit the unsuitable. For example, the sum chosen in the previous paragraph to represent this type of sum is quite foolish. Who on earth wishes to fill and to empty a bath at the same time? Why ask a boy to do a sum which, if he is at all intelligent, he will condemn as absurd? (*b*) It is self-evident that games and puzzle sums will prove pleasurable and will maintain the voluntary interest of the pupils. (*c*) Children today, with their ever-widening outlook, due to the cheapening and increase in the number of books, to the excellence of children's modern books, to the radio, and to the cinema, are much more interested than any generation before in a knowledge of the world. Sums of a general-knowledge character will appeal to them. (*d*) A vast variety of sums concerning the child's school and home life, the industries of his relations and friends, the sports of his area, can be compiled to add interest to his number manipulations. (*e*) Social services such as the post office, the railway, the omnibus, the gas and electricity supply; national savings; civil aviation; the general life of the country; all offer a field for the composition of sums which cannot fail to catch the attention of the pupil.

All these types of sums can be presented to the child with the assurance that, if they are suitable to his age, he will be interested in doing them.

There are some other very vital points relative to problems which must have our consideration.

1. The setting of a word-sum is quite a skilled operation. An exact answer is required, therefore an exact question must be stated. There must be no ambiguity. What is the answer to this sum? "A boy did 40 minutes' piano practice every day. How many hours did he practise in a month?" Neither you nor I know. It depends on the month. In that month he may have practised 28, 29, 30, or 31 times 40 minutes! No sum must be stated in such a way that it baffles the pupil. A child does not easily determine that "How many times is 9*d.* contained in 5*s.* 3*d.*?" is a division sum. The word "times" at once suggests multiplication. The pupil would be less liable to err if the sum read, "Into how many ninepences can I divide 5*s.* 3*d.*?" The phrasing of a sum must agree with the mental age of the child. A first-year scholar will find "How many less in 48 than in 81?" far more difficult than "How many more in 81 than in 48?" and he will prefer, "14 marbles, 25 marbles, 13 marbles. How many marbles altogether?" to "What is the total of 14 marbles, 25 marbles, and 13 marbles?"

In mechanical work children use the signs $+$, $-$, $\times$, and $\div$. In the prob-

lems set them the same significance is expressed in a great many ways. The + becomes total, added to, together, altogether, how many, how much; the − becomes difference, remainder, more than, less than, subtract, how much left, how much shorter, how much heavier, how much change; the × becomes multiply, find the product, how many, how much; the ÷ becomes divide, find the quotient, how many in one, how much. It will be noticed not only that many expressions are used, but that some of them are utilized to ask questions irrespective of the process which will be used to work the sum. Are not these phrases liable to confound the pupil? They certainly will not help him. Would it be advisable to limit their use, that is, to form a special arithmetical vocabulary? Maybe that would give a clue to each type of sum and thus save the pupil from thinking, which is the very thing we want the pupil to do. The present several uses of the same words must be baffling to the less intelligent scholars, as shown in the following example which was set for an external examination of children of 9+ to 11+ years of age. "Take £32 15*s.* 4¼*d.* from £200 and divide the remainder by 45." "Remainder" is the answer to a subtraction sum, but it is also used to denote what is left over when division has been done. In the example just quoted "remainder" coming so closely after "divide" was not too happy a choice of word.

2. In some text-books are exercises of what are termed "narrative problems." Here is an example. "We Brownies went on an outing to Burnham Beeches. It cost each of us for coach fare 1*s.* 9*d.*, for tea 9*d.*, and for a swim in the baths 6*d.* (*a*) How much did the outing cost each of us? (*b*) There were 10 of us. How much did it cost us altogether? (*c*) Our leader had to pay twice as much for everything as we did. What did she pay altogether?" There is an objection to this type of exercise. It is that should the first answer be wrongly found, the answer of the sums following will all be wrong also. That is perfectly true. But the value of the exercise heavily outweighs the objection. In the first place the story factor will give added interest to the work. In the second place it should be pointed out to the class that more than usual care must be taken in doing the sums, for errors in one sum will result in errors in the others. Instead, therefore, of objections being made to "narrative problems," they should be welcomed. They offer greater interest and demand more intense attention to accuracy.

3. How should problems be done? Should they find a place during the "mental" period, or should they be done orally, or should they be written? Some are suitable only for mental work. In fact, some should be composed solely for mental solution: they should be used to introduce scholars to new work and the more difficult problems which need to be written. It may be necessary to work new types orally, that is, with the entire class. But any sum set for the pupils to do individually should never be explained first or done orally. The child must face a problem unaided. If, however, the class as a whole finds a problem too difficult of solution, the oral should be reverted to. But the help given should be rather a demonstration done concretely than a written solution of the sum puzzling the pupils.

With regard to the problem to be worked out on paper, that is the final form in which problems should be worked out. It is the form used in adult life, for few are the mathematical geniuses who can work life's problems mentally. Therefore, in the school, the "mental" and the "oral" should be ancillary to the "written" problem.

4. Problems should be varied. They must not on any process be all of one type. For problems cannot be taught: if it is assumed that they can be, then they are not problems. It must not be that children learn a set type, and then do example after example of that one taught type. Such work becomes purely mechanical, as mechanical as the unworded sum, and defeats the object of the problem.

5. When a child is confronted by a problem, what must he do? The teacher must train him to read the problem carefully, so to get into his mind all the facts contained in it, and what he has to find out. Until he comprehends the meaning of the problem he cannot possibly solve it. That comprehension can result only from a careful, exact reading of the problem. Then the child analyses the problem into its two parts: what he is told, and what he has to discover from the facts given him. Next he must, along logical lines, put down his working What would be a successful, satisfactory setting out of the following sum? "A copper wire is wound round a large reel 56 times, the distance around the reel being 3 ft. 9 in. If the wire weighs 2 oz. to the yard, what is the weight of all the wire on the reel in lb. and oz.?" A solution of the highest value would be:

What is the weight in lb. and oz.?

	Multiplication.	Reduction.
Length	$= 3$ ft 9 in. $\times 56$	$= 1\frac{1}{4}$ yd. $\times 56$
		$= 56 + 14$ yd.
		$= 70$ yd
Weight	$= 70 \times 2$ oz.	$= 140$ oz.

$$\begin{array}{r} 8 \text{ lb.} \\ 16)\overline{140} \\ 128 \\ \hline 12 \text{ oz.} \end{array}$$

The weight of the wire is 8 lb. 12 oz.

That is an example of logical thinking. Having analysed the question, the child notes and writes first at what conclusion he must arrive. He then determines that the methods to be used will be multiplication and reduction. The steps of these methods are shown, and the names of units written so that mistakes are avoided.

It should be noted that the sum is set out symmetrically. All the "equals" are underneath one another. That is as it should be. Pride of style in writing a sum assists accuracy.

There is much laxity among children in the use of the sign =. Such work as

$$7 \times 9 = 63 + 18 = 81 \div 9 = 9 + 2 = 11,$$

although obtaining the correct answer, must never be tolerated. It is not arithmetic, for arithmetic is an exact science, and can only permit within it that which is true. $7 \times 9 = 63 + 18$ is not true. Therefore it is not arithmetic. The pupil needs much guidance as to the meaning of the sign. It might be likened to the pivot of a see-saw. The plank of the see-saw must be in a straight line. It must not have a heavy child at one end and a light one at the other In fact, it must be so balanced that it will not operate as a see-saw. Or the = might be compared to the knot in

the middle of a tug-of-war rope, pulling on which are two teams so equal in strength that neither pulls the other one inch. Again, it could be the sign placed between 12*d.* and 1*s.*, but not between 13*d.*, or 11*d.* and 1*s.* Or again, it might be the upright body of a man who is carrying equal pails of water in each hand, but not of the man who is carrying one pail, for he throws his body to one side in order to maintain his balance. Other concrete examples will suggest themselves to the imaginative teacher, and they are necessary, for the sign = must not be ill-used.

6. Problems should not be divorced from life. Exactly as the child will be interested in writing a composition centred in some circumstance in which he found himself, so will he be interested in the sum which is connected with some part of his activities or environment. Sums should be topical, but topical of the surroundings. The city child who has not experienced the delights of the country will find little pleasure in working sums dealing with farm life, as the country child will not be entertained by the sum connected with life in a densely inhabited industrial area.

7. Let us conclude this chapter with a consideration of examples of problems suitable to children in each of the four years of their Primary School life.

(*a*) The First Year:

1. 28 days in February, 31 in March, and 30 in April. How many days altogether?

2. How much more are 6×7 than 18?

3. How many fingers and thumbs have 6 children?

4. In Tom's purse is 1*s.* $7\frac{1}{2}$*d.* In his money-box is 4*s.* $8\frac{1}{2}$*d.* How much money has he?

5. Take 76 marbles out of your bag and place them in 4 equal heaps. How many marbles in a heap?

6. Jane had 3*s.* 0*d.* She bought a book which cost 1*s.* 9*d.* How much money had she left?

(*b*) The Second Year:

1. Mr. Black, the greengrocer, sold 236 oranges on Monday, 78 on Tuesday, and 159 on Wednesday. How many did he sell in the three days?

2. There are 600 children in our school: 317 are girls. How many boys are there?

3. Our class collected £1. We bought a football for 13*s.* $7\frac{1}{2}$*d.* How much money have we left?

4. There are 384 cigarette cards in 8 sets. How many cards are there in each set?

5. Jim hopped 3 ft. 10 in., stepped 2 ft. 4 in., and jumped 5 ft. 3 in. How far did he go altogether?

6. One shelf in our cupboard will hold 68 books. How many books of the same size can be placed on the 6 shelves?

7. Mother paid 11*s.* 3*d.* for 3 sacks of coal. How much did she pay for each sack?

8. I am 4 ft. 6 in. tall. My sister is 2 ft. 10 in. tall. How much taller am I than my sister?

(*c*) The Third Year:

1. When you play "fives and threes" with dominoes, 12 dots score . . . . , 15 dots score . . . . , 8 dots score . . . . , 4 dots score . . . . , 20 dots score . . . .

2. Tom earned 15*s.* 9*d.* a week. Out of it he gave his mother 12*s.* 6*d.*, and

spent the rest. How much did he spend in a month (4 weeks)?

3. If in Question 2 Tom had saved half of what he spent and bought *6d.* National Savings Stamps, how many stamps would he have bought?

4. If 12 girls in their needlework lessons use 59 yards of cotton from a reel, how much cotton does each use?

5. In one year (1936) the number of people killed on the road in various vehicles was: private cars 1,965; motor cycles 1,374; buses 478, vans and lorries 1,416; bicycles 1,095; trams 97; taxicabs 23. How many were killed altogether? (The numbers in this sum are fictitious: they may be obtained from a Year Book.)

6. The number of people killed in 1927 was 5,176; in 1934 it was 7,468; and in 1935 it was 6,479. How many more people were killed in 1936 than in 1927? (See Question 5.)

7. The bill for 8 teachers' chairs and 1 armchair was £4 10*s.* 1*d.* If the armchair cost 18*s.* 9*d.*, how much did each of the teachers' chairs cost?

8. A row of seeds in my garden is 9 yd. 2 ft. 10 in. long. What length of netting shall I need to cover 5 rows the same length?

9. In a line of a book are 9 words; on a page are 34 lines; in the book are 16 pages. How many words are in the book?

10. From the time-table given, what is the last bus I can catch from the Marble Arch to Great Missenden?

11. At our last school football match we collected 17 sixpences, 5 threepences, 83 pennies, and 39 halfpennies. How much was the collection in £ *s.* *d.*?

12. How many pint bottles can a milkman fill with what is left from 25 gal. 1 qt. when he has sold 16 gal. 2 qt 1 pt.?

(*d*) The Fourth Year:

1. In 1937 the pupils in this school made these attendances during the four quarters of the year: 21,336, 19,989, 22,605, and 21,474. What was the total attendance for the whole year?

2. If 18,650 passengers arrived by aeroplane at Croydon in 1934, and in 1935 there were 20,139, how many more arrived in 1935 than in 1934?

3. Find the total cost of:

6 boxes of pens at 5*s* 9*d.* a box.

1 gross of pencils at 1*s.* 6*d.* a dozen.

4 dozen paint-brushes at $4\frac{1}{2}$*d.* each.

$\frac{1}{2}$ lb. rubbers at 5*s.* 9*d.* a lb.

4. If a gallon of honey weighs 12 lb., how many gallons of honey must the bees make to weigh a hundredweight?

5. A boy took $\frac{1}{4}$ of an hour to do one sum, $\frac{1}{6}$ of an hour to do another, and $\frac{1}{12}$ of an hour to do a third. How many minutes altogether did the boy take to do his sums?

6. Copy the plan of a football pitch. What is its area? Could you get 10 such pitches in an acre?

7. From your house it takes 12 minutes by bus to get to the station, 1 hr. 25 min. by train to London, 18 min. by bus across London, 2 hr. 58 min. from London to the seaside. At what time must you start from your house to be at the seaside at 4.30 p m ?

8 (A catch question.) If there are 18 lamps down one side of a street, and the distance between each pair of lamps is 35 yards, what is the distance between the first and last lamp?

9. 335 children will attend our school sports. How many gallons of tea will

have to be made to allow each child two-thirds of a pint?

10. If an aeroplane travels at 300 miles an hour, how long will it take to travel the 225 miles distance between London and Paris?

11. Our home ciné-projector and 3 films cost £5 12*s.* 0*d.* The same projector and 8 films cost £7 17*s.* 0*d.* How much was the cost of the projector, and how much the cost of one film?

"Narrative" problems:

12. A man bought a piece of ground for £203 10*s.* 0*d.*, built a bungalow for £750, and bought a motor-car for £188 17*s.* 6*d.* How much did he spend altogether?

13. In Question 12 how much more did the bungalow cost than the motor-car?

14. How much will the man in Question 12 have left from £1,500?

CHAPTER THIRTEEN

INSTRUMENT WORK

A PERCENTAGE of children in our schools show no interest and make no progress in arithmetic, because they see "no sense in it." They say so, with no hesitation in their affirmation. Until they change that attitude, until we can interest them, until we can prove to them that there *is* "sense in it," their co-operation will never be ours. Their progress will continue to be nil.

These children must be converted from their damaging conviction. They must have our consideration. We must make a special approach to them. It is possible that they, who certainly are not mentally deficient but who have at least an average of intelligence, could be influenced to appreciate arithmetic if they received their teaching from a different angle. Most children like "doing" things. The children of whom we are thinking should "do" arithmetic, that is, they should work as much as possible practically.

No doubt it would interest them to know that men and women for many centuries have not only been engaged in more or less abstract calculations, but have also been doing this practical side of arithmetic. The papyrus of the Egyptian Ahmes, written some 4,000 years ago, tells how to find the cubical contents of barns, necessary to be built for the storage of grain, how to measure land, which was an operation continually necessitated by the flooding of the Nile, how to build a monument or temple exactly orientated. From that time onwards men of other nations were interested in squares, and oblongs, and circles, and triangles, and their interest culminated in the books of that master of mathematics, Euclid. These mathematicians found pleasure in "doing" arithmetic, in drawing arithmetic, in the arithmetic of measurement. Their chief interest was in that section of number work called Geometry and Mensuration.

That work did not die with them. Today men and women in the ordinary business of life are compelled to do what *they* did voluntarily. Measuring enters into the occupation of the knitter, of the seamstress, of the tailor, the railway builder, the road-maker, the surveyor, the nurseryman, the ship-builder, the bridge-builder, the architect, the men engaged in the construction of the various parts of a house, the toolmaker, the draughtsman, the printer, and so on, and so on. There is scarcely an occupation in which no *measuring is done. One might almost* term it the universal factor of occupations.

Not only were Euclid and Pythagoras and the other advanced mathematicians interested in measurement, but the "man in the street" was enforced to be also. No standard lengths existed for his use. He had to improvise, and sensibly, as he did for counting, he used

his natural possessions. The Bible gives many clues to man's ways of measurement. In Jeremiah lii. 21 we read that the thickness of some pillars in a temple was *four fingers,* and a finger measured about $\frac{3}{4}$ of an inch. A part of a table, we are told in Exodus xxv. 25 was to be bordered about a *hand-breadth,* that is four fingers' breadth, which is roughly 3 inches. A breastplate was to be constructed a *span in breadth* (Exodus xxviii. 16). A span equalled three *palms* or 9 inches. Two spans made a *cubit,* which is first referred to in Genesis vi. 15, where the measurements of Noah's Ark are detailed. A cubit was the distance from the elbow to the tip of the long finger, and measured 17 or 18 inches. Four hundred cubits made a *furlong* (Luke xxiv. 13), which was the distance oxen could draw a plough before a rest for them was necessary. They ploughed a furrow-long. A furlong was also equal to 450 paces, one of which is now reckoned at 2 ft. 6 in.

Another unit of measurement was the *hand,* and that is still used to state the height of a horse. It is said to be "of so many hands." The width of the hand was 4 inches, that is, it was one and one-third times the palm.

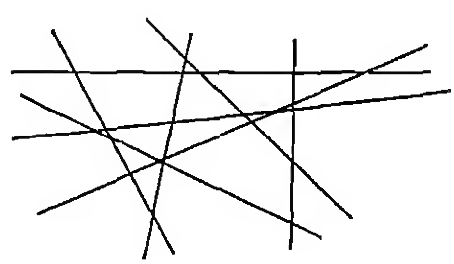
Thus the old units of length were a finger, a hand-breadth or palm, a hand, a span, a cubit, a pace, and a furlong. These should be described to children, and they should be informed that although the measurements varied from person to person and were thus very inexact, they were sufficient for the needs of those old times. The pupils should find their own personal measurements of these units and realize that always they carry with themselves definite lengths which may be called upon should occasion arise. Added to these measurements should be their height, and the distance from finger-tip to finger-tip when the arms are fully stretched sideways.

It is not to be presumed that the only value attaching to practical work, entailing the use of instruments, is to interest the uninterested. That is not so. Such work is useful in many another way, which will become evident as this chapter proceeds.

The introduction to instrument work should be by way of the ruler.

First Year

STEP 1. Children should draw with the aid of a ruler a number of straight lines (not more, say, than 15) of any lengths. The lines may be parallel, may cross, may be vertical or diagonal or horizontal, that is to say, they may be drawn in any or all directions. The exercise may well be turned into a competition. A child draws his lines, counting their number as he does so. It is the business of other children of the class to guess how many have been drawn. The competition idea is quite incidental; the aim of the exercise is one only, and that to teach children that with a ruler they are able to draw straight lines.



STEP 2. This step will demonstrate the second use of the ruler, namely, the

measuring of lines. This exercise should not be passed over lightly. It is essential. Children are commencing to work on a new idea with exactness. No doubt they have used previously the words "long," "longer," and "length." Now they have to ally to these words definite, exact, measured units.

The ruler has marked on it a number of long lines, and by the side of each is a figure. From one long line to the next is a distance of one inch. Two facts are in that statement, and they are not readily understood by many children. First, they do not comprehend the meaning of "distance." To help them the teacher should draw on the board a long line. He should show that by moving along that line one travels a distance. A cut-out insect walking along the line might be introduced. Again, a line might be drawn on the floor, and a child told to walk a distance (not an exact one) along it. The idea of length is fundamental: it must be stressed.

The second fact of the sentence that baffles children is "that it is one inch from one long line to the next." To them, from the line marked 1 to the

line marked 2 is two inches. There are two marks; therefore, they argue, there must be two inches. That error of ruler reading must be corrected at the very outset of instrument usage. Recently I saw some work done by boys of 8+ years of age. One exercise they had to do was to draw a line 7/8 of an inch long. When the lines drawn were measured they were found to be exactly six-eighths of an inch. The error was not due to careless drawing: the boys explained how they had measured—they had counted marks and not the spaces between the marks. That brings us back to the first misconception. Children do not intuitively understand measured distance.

If, after pupils have done Step 1 and have received further guidance in the understanding of length, errors of dot or mark counting instead of spatial measurement persist, other steps must be taken to give a clear idea of distance. Children can do no useful work until there is perfect understanding of the length notion.

The aid of the physical-training lesson could be solicited. (*a*) Put a large chalk mark on the playground and let children make from it a standing double-footed jump. Measure with a piece of string—not with a ruler or tape-measure—the distance jumped. The string will not measure exactly, but comparatively, and the longest distance jumped can be found. (*b*) Line up some 10 children in a rank. On the word "go," let them run forward. Test "how far" or what "distance" they can run in 10 seconds. (*c*) Similarly, line up another 10 children. Let this team

hop on one foot for the same 10 seconds. Compare the "distance" with that which was run by the first team. (*d*) Let a third rank for the same time hop forward with both feet together. (*e*) Other similar exercises could be devised. Frequently, during the exercises use the words "distance," "how far," "length." (Do not use the word "cover" in such a phrase as "How far did Jim cover?" Leave that word until "area" work is being done, so that the idea of "space covered" can be formed.)

1. ———————— $1\frac{1}{2}$ in long.

2. ———————————————————————— 3 in. long.

3. ——— $\frac{1}{2}$ in. long.

4. ————————————————————————————————— $4\frac{1}{2}$ in. long.

Now to return to the actual exact ruler measurement. Children should make for themselves in a handwork lesson a 4-, 5-, or 6-inch ruler of stout paper. An oblong an inch wide and 4, 5, or 6 inches long should be drawn and cut out. The oblong should be marked in the requisite number of inches, and inches only. The production of this ruler will not only give an exercise in measurement, but will also make the class intimately connected with the instrument itself.

With a purchased ruler or with the constructed one, children should then draw lines of various lengths, from 1 to 6 inches, not in progressive order. During this exercise reference should be made to the distances run and hopped and jumped in the physical-training lesson. It should be pointed out that with the ruler the lengths can be measured exactly.

In a lesson of practical inch measuring, children should become acquainted with the fact that the greatest distance across a halfpenny is exactly one inch. They should measure the coin and realize that being possessed of such a coin they always have a means of making an exact inch measurement.

STEP 3. Half-inches are introduced in this step. Reference can be made to other halves the scholars have experienced, such as half a penny, half an orange, half an hour, half a cake. Lines of various inches and halves should be drawn: $1\frac{1}{2}$ in., $3\frac{1}{2}$ in., $\frac{1}{2}$ in., $4\frac{1}{2}$ in.

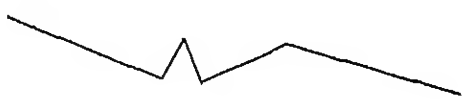
Exact work should be demanded of the pupils, and the production of that exactness will be more probable if there is a ruling that the execution of the work must be in proper order. The length of the line should always be written in connection with it.

A third type of exercise should be introduced into this step.

(*a*) Draw a line $1\frac{1}{2}$ in. long. Add to it a line $2\frac{1}{2}$ in. long. How long are the two lines together?

(*b*) Draw a line 4 in. long. Put a dot $3\frac{1}{2}$ in. from one end of the line. How far is the dot from the other end of the line?

(*c*) A fly walked along this line. Draw it and find out how far the fly walked.



(*d*) Draw a line 7 quarter-inches long. How many inches are there in it?

(*e*) Measure an envelope and draw it

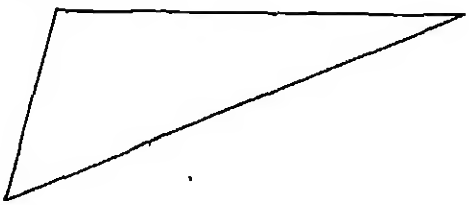
(*f*) Draw a square, side $1\frac{1}{2}$ in. (Show the children how to fold a stiff piece of paper in such a way as to make a "square corner." (This prepares the way for a right angle.)

(*g*) Draw these lines. How much longer is line A than line B?

A B

(*h*) Draw this line. Put a mark just at the middle of it.

(*i*) How far is it round this shape which has three sides?



Another exercise is that of the type on page 48, Book I, *Junior Workaday Arithmetic*. There is depicted a large clock, with case and hands of exact inches and half-inches. Various questions requiring the measurement of the lengths of the case and hands are set.

Many children when first using a ruler get into the habit always of measuring from the beginning of the ruler. That is, they use the first inch and appear to think it is imperative to do so. It should be stressed that all the inches on the ruler are of the same length, that any part of the ruler may be satisfactorily used for the measurement of a line, and that often it is very convenient to use the central inches and not the end of the ruler.

Second Year

It is essential that children are instructed in the proper use of the ruler. (*a*) They should learn that the bevelled edge is to allow ink drawing to be done without smudging the drawn line. (*b*) When putting a dot for the beginning or end of a line, or when drawing a line, the pencil should be held vertically. A slanting pencil produces inaccuracy of length, for the marked dot will not be exactly opposite the mark on the ruler.

STEP 1. Following recapitulation of the lengths of inches and halves, quarters should be introduced. They should be connected with the already known quarters of a penny.

Again, correlation with the handwork lesson is possible. A ruler should be made marked in inches, halves, and quarters. The cut-out should be $\frac{1}{2}$ inch wide, and from 4 to 6 inches in length. Children should be led to notice that the marks on the ruler are of various lengths. They should be questioned to make them observe for which divisions the lines are longest, are of medium length, are shortest. It should be inquired of them why various lengths are needed and why they are helpful.

Lines, involving quarters, halves, and inches should be drawn (Fig. 15).

STEP 2. This step introduces halves of quarters, that is, eighths. Once again it would prove of value to make a ruler and to mark it off in eighths. The comparative lengths of the marks on a

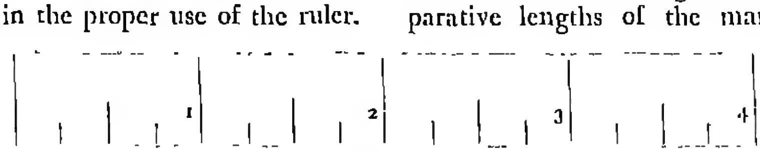


Fig. 15.

ruler showing eighths should be observed.

Questions such as the following should be set:

(*a*) Draw a line 1 inch long. Mark it off in eighths. How many eighths?

(*b*) Draw a line $1\frac{1}{2}$ in. long. How many eighths in the line?

(*c*) Draw a line $2\frac{1}{4}$ in. long. How many eighths in this line?

(*d*) Draw a line 16 eighths long. Write how long the line is in another way.

(*e*) Draw a line $\frac{3}{4}$ in. long. Add to it a line $1\frac{1}{2}$ in. long. How many eighths in the lines together? How many more eighths in the second line than the first?

With the help of the ruler work these sums, $\frac{1}{8}+\frac{1}{8}=\quad$; $\frac{1}{4}+\frac{1}{8}=\quad$; $\frac{1}{8}+\frac{1}{2}=\quad$.

Another type of exercise, which will be useful to the teacher of geography, and will correlate with his scheme, is this:

(*a*) Put a dot near the middle of a line on your page. From it draw a line $1\frac{3}{8}$ in. to the west, and from it another line $1\frac{1}{4}$ in. to the east. How long are the two lines together?

(*b*) Put another dot and call it A. From A draw a line 1 in. to the north and call the end of it B. From A draw another line $1\frac{1}{8}$ in. to the south and call the end of it C. How far is B from C?

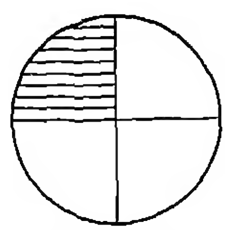
(*c*) From a dot E draw a line $\frac{7}{8}$ in. to the east to dot F. From F draw a line $1\frac{3}{8}$ in. south to dot G. From G draw a line $\frac{7}{8}$ in. west to dot H. Join dot H to dot E. How far is it all round your drawing?

For a further type of sum, that on page 38, Book II, *Junior Workaday Arithmetic*, is suggested. It is of the front of a doll's house, and questions are asked relative to the lengths and widths of windows, doors, walls, etc.

The teaching of quarters and eighths of inches, and the revision of inches and halves, complete the scheme for the second-year "parts of inches" ruler work. Simultaneously with this work should be set simple exercises involving vulgar fractions. The type of work of Steps 1 and 2 just described is of great importance to the introduction of fractions. The children will learn an extension of their $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ in connection with pence, to $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, $\frac{1}{8}$, $\frac{3}{8}$, $\frac{5}{8}$, and $\frac{7}{8}$ of inches. In so doing they will be unconsciously imbibing the manner in which fractions are written. They should be learning, too, that we usually write not $\frac{2}{8}$ but $\frac{1}{4}$, not $\frac{4}{8}$ but $\frac{1}{2}$, that is, we express a fraction in the simplest of terms, although there are other ways of writing it giving it the same value.

When quarters and eighths of inches are being drawn, quarters and eighths of other wholes should be associated with them. For example, the following exercises would fit in admirably immediately after such measurements had been ruled.

(*a*)



1. Into how many parts is this circle divided?

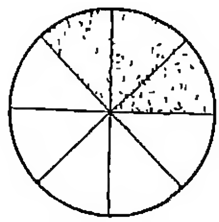
2. How shall we write what part of all the circle each part is?

3. What part of the circle is left white?

4. What part of the circle is shaded?

5. Which is greater, the shaded or the unshaded part?

(*b*)



1. Into how many parts is the second circle divided?

2. What can we call each part?

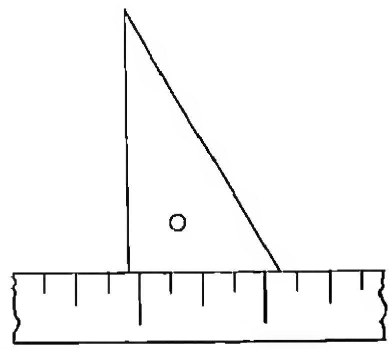
3. What part of the circle is dotted?

4. What part is undotted?

5. How many more parts are undotted than are dotted?

6. What shall we write to show how many more parts are not dotted than are dotted?

STEP 3. In this second year, squares and oblongs should be drawn. The square, which is explained as a shape with four equal sides and four square corners, can be drawn by the children in at least three ways. (*a*) With a ruler. Draw the lowest horizontal side of the square. Place the ruler above and touching the line, and move it along until the end of it coincides with the end of the line. Draw a vertical line up the end edge of the ruler. Do the same at the other end of the horizontal side. Join the tops of the vertical lines. (This method can be used only if the ruler is a perfect one.) (*b*) With a ruler. If the inches on a ruler are marked completely across the ruler or if the middle inch is so marked, the inch lines may take the place of the ends of the ruler for the drawing of the vertical sides. (*c*) With a ruler and a set-square. If a set-square is available, it can take the place of the end of the ruler of method (*a*), or of the inch marks of method (*b*). But the class should be taught how to use the set-square properly. Children should not be allowed to draw round the set-square. The horizontal side of the square is first drawn. The ruler is then placed below it, and the set-square slid along the ruler until it coincides with the square's horizontal side. By one of these methods, preferably the last, squares and oblongs of various dimensions should be constructed. Their sides should be of the inches and parts of inches already taught.



STEP 4. Plan drawing, leading to map drawing and correlation with geography, and drawing to scale should form the next exercises. Objects of the classroom, such as a pupil's desk, the teacher's desk, a table-top, should first be chosen. A scale such as 1 inch to 1 foot would probably be suitable. The class, at this stage, should receive considerable help in working out the scale lengths of 9 inches, 6 inches, and so on.

The drawing should be explained as a "plan": a drawing of something seen not sideways but from above, a drawing of a field or the roof of a house or a river or the seashore or a lake as seen by an airman passing over in his aeroplane, a drawing of the tops of buses and motor-cars and cinemas and dogs and human beings as seen by a bird when flying over a town. This work and explanation will be welcomed

by the geography specialist as a first step towards the children's understanding of his maps.

Third Year

STEP 1. The fractions of an inch to be taught and used in ruler work are thirds, and their subdivisions sixths and twelfths. The method of approach should be similar to that of previous years. One other fraction is included in the scheme, namely, the tenth. Intentionally it is brought into the practical work to lead concretely to the second form of fraction, the decimal.

First a ruler, divided into tenths, should be made in the handwork lesson. Then should be drawn lines of various lengths, as $1\frac{3}{10}$, $2\frac{7}{10}$, $\frac{8}{10}$ inches, and so on. There should follow the explanation that these fractions, and not the quarters, thirds, etc., can be written 1·3 inches for $1\frac{3}{10}$ inches, 2·7 inches for $2\frac{7}{10}$ inches, and so on. The next exercises can then be expressed in this way.

1. Draw lines measuring 1·4 in., 2·1 in., 3·9 in.

2. Draw a line $2\frac{0}{10}$ in. long.

3. Draw a line 2·6 in. long.

4. What is the difference in length between the lines in questions 2 and 3?

5. Construct a square whose sides are 1·4 inches.

6. Draw an oblong with length 2·5 inches and width 1·8 inches.

STEP 2. Having drawn squares and oblongs in the second year, consideration of their areas can be made in this third year. To a child the idea of area is not easy; very careful, progressive, and thorough work must be done. The perimeter and the area of a rectangle are often confused; the difference must be clarified at the outset. The idea of an empty space enclosed by four straight lines must give place to the idea of a space covered. Until children are convinced that area has this meaning of the covering of a space they will never understand its two-dimensional character.

This subject will not receive further consideration here; its proper place is in the chapter on "Measures."

STEP 3 Work that is full of interest can be done with the ruler and set-square. At the same time practice in measuring parts of an inch can be included. Such an exercise as the following never fails to give pleasure.

1. On a piece of plain paper draw a square of 3-inch side exactly (Fig. 16).

2. Now draw in the square the extra lines given in the diagram. Be sure all your measurements are accurate.

3. Cut out the square and cut very exactly along all the lines you have drawn. You will have seven pieces.

4. Try to put the pieces together again to form the 3-inch square.

5. Place the seven pieces in an envelope, take them home, and ask your parents and friends to put them together to form a square. Time them to see who can do the puzzle most quickly.

Children should be given the opportunity of inventing their own puzzles. A 3-inch square is a suitable size for the drawing, but other sizes of squares and oblongs may be chosen. The number of pieces into which the shape is to be cut should be limited. A competition might be conducted to discover which child's puzzle is the most ingenious and which gives his fellow pupils most difficulty in reassembling.

STEP 4. There is scope for further plan and scale drawing. The school

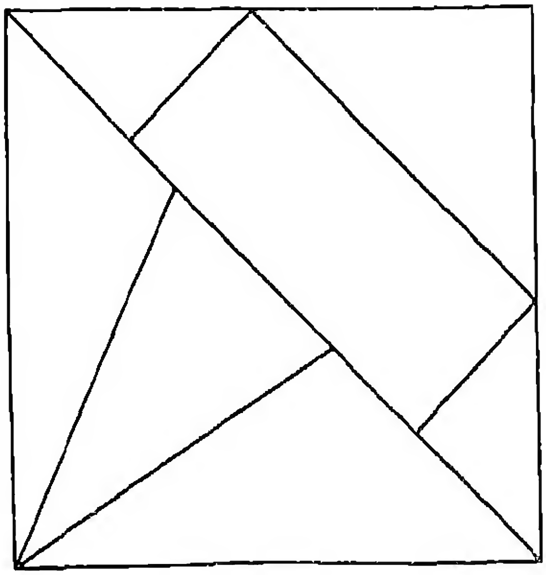


Fig. 16

to pace their way home, and from the lengths of their paces distances in yards could be obtained. The result might be something like Fig. 17.

Scale: 1 inch to 100 yards.

Questions such as the following could then be answered by the whole class:

1. How far has Sam to go to school? (Measure along the middle of each road.)

2. What distance does Kate go each day if she goes to school both morning and afternoon?

3. How much farther has Fred to go than Mary?

hall with its piano, platform, and cupboards could be measured and planned. A first attempt at map drawing could also be made. Children could be asked

Fourth Year

STEP 1. The work of this year includes revision of that done in previous years—measuring in inches and parts of inches, plan and scale drawing, and the

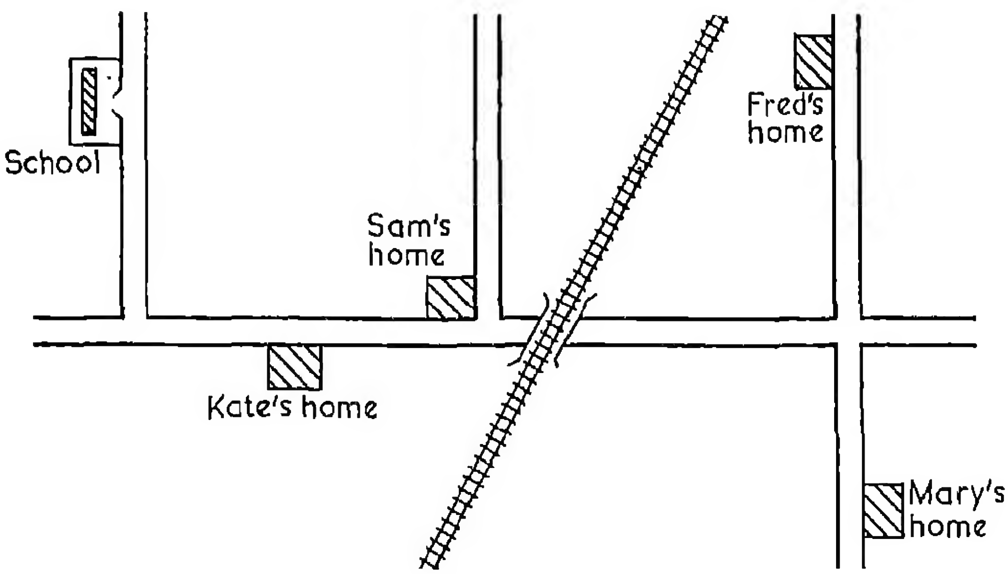


Fig 17

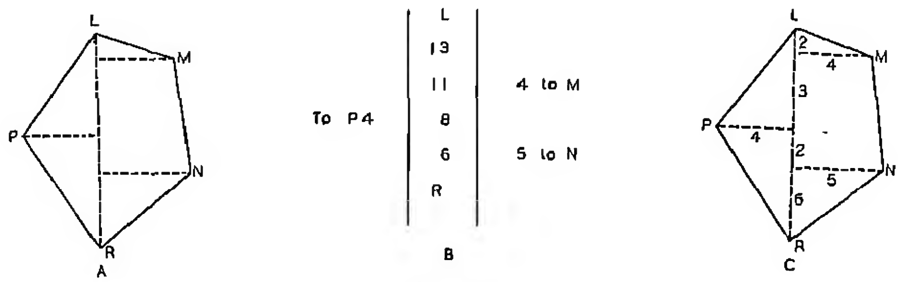
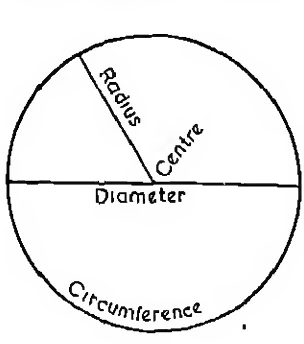


Fig 18.

making of puzzles. Material suggested for the plan and scale drawing is a schoolroom, the school playground, the school garden, the school building, parts of playing-fields and recreation grounds.

In connection with scale drawing the making of a "chain book" forms a good exercise, and creates a link with outdoor geography work (Fig. 18). With a chain (22 yards) the dimensions of a field are found. A central line across the field is measured, L R, and from it offsets to the corners of the field, at right angles to the central line, are then measured as in A. As measuring is done, the results are set out in a "chain book," as shown in B. From this the field is drawn to scale as at C.

Step 2. Other instruments are now introduced. The first is the compass. Circles of various radii are drawn. The terms circle, centre of circle, radius,

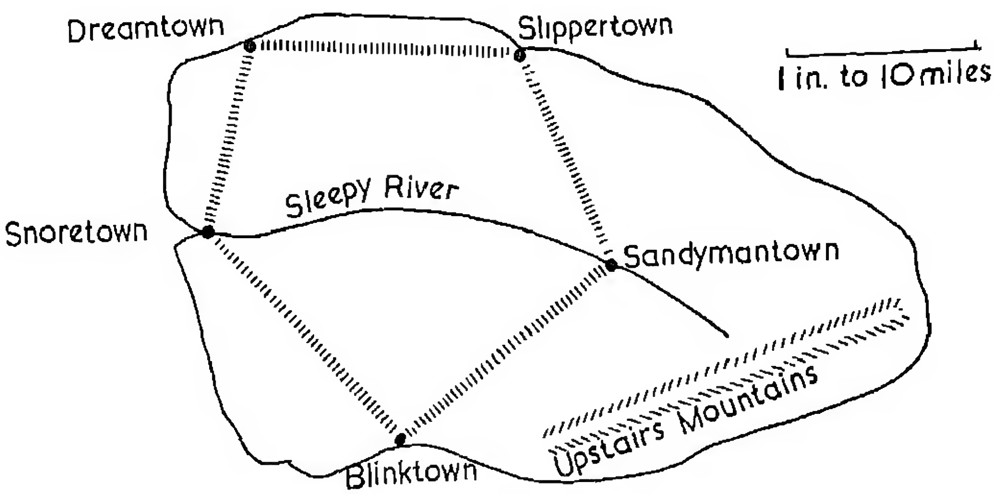


diameter, and circumference are taught. It is also shown that the compass, with a radius equal to the radius of a circle drawn, will step around the circumference exactly six times. By joining the points of the steps a hexagon may be formed. This fact also makes possible the production of ingenious and delightful designs, specimens of which are shown in a later chapter on the correlation of arithmetic and art.

Another use of the compass should be demonstrated, namely, that of drawing arcs from the end of lines so that perpendiculars may be constructed. In this connection the words "horizontal" and "vertical" should be used. Exercises, including the drawing of squares and oblongs, should be worked. It should be shown that this method of forming a rectangle is preferable to methods previously learned.

Step 3. With the introduction of the use of the protractor, angles of different degrees can be drawn. Triangles of sides of given length and of angles of given degrees can be constructed, following the instruction in the use of the protractor.

Step 4. Drawings of shapes for area finding, and for cutting out to form cubes for volume calculation, should be done. They will be further considered in the chapter on "Measures."



MAP OF DREAMLAND

STEP 5. The planning of streets which formed part of the third-year work should be extended to map reading and construction in this fourth year. Such an exercise as the following will prove valuable and interesting.

1. With a piece of cotton measure the coastline of Dreamland, and using the scale find how far it is all round the island.

2. In the same way measure and find out how long Sleepy River is.

3. How far is Dreamtown from Slippertown?

4. If I go from Blinktown by railway through Sandymantown to Slippertown, how long is my journey?

5. How long are the Upstairs Mountains?

6. What is the distance from Blinktown to Snoretown?

7. How far from the mouth of the Sleepy River is the bridge at Sandymantown?

Other exercises of a like nature will be found on pages 57 and 61, Book IV, *Junior Workaday Arithmetic*.

Finally, scale drawing can be connected with the making of sections from contour lines on Ordnance Survey maps. Connection in this particular with geographical work will be most valuable.

FRACTIONS

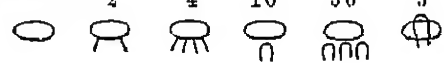
FRACTIONS can be stated numerically in three ways, as vulgar fractions, as decimals, and as percentages. They are all forms of the same thing, and should be taught so that their relationship is understood. The order in which they were historically used is vulgar fraction, percentage, and decimal. We shall consider them in the order vulgar, decimal, and percentage, for the last is a limited kind of fraction, in that its denominator is always the same. The most varied kind is the vulgar fraction; in it may be used any number to infinity. The decimal is more limited; its denominators are in essence tenths, hundredths, thousandths, and so on. The percentage has solely the denominator of 100.

Children take a long time to feel confident in the writing and the meaning of fractions; so did the human race. Man early formed an idea of "parts" and of fractions with a unit, i.e. a "one," numerator; children do likewise. The difficulty came and still comes similarly when more than one unit of a part is considered: $\frac{1}{8}$ of an amount is quite readily understood; the meaning of $\frac{5}{8}$ of an amount comes only after much explanation and thought.

The word "fraction" had its origin in "frangere," the Latin for "to break." So a fraction was a piece "broken off" a thing. There was nothing exact in the early idea of a fraction. It was simply what the name called it, "a bit broken off." This idea persisted until the Middle Ages, when fractions were known as "broken numbers."

The Egyptians attempted a notation for fractions, but they were able only to represent those of the unit type, except for two-thirds. From Egyptian hieroglyphics we learn that the following fraction signs were used:

Fraction $\frac{1}{2}$ $\frac{1}{4}$ $\frac{1}{10}$ $\frac{1}{30}$ $\frac{2}{3}$



These signs can be connected with the signs for the cardinal numbers:

two four ten thirty

For two-thirds, it will be seen, the fraction sign was crossed by the sign for ten. What is the connection between the sign and two-thirds? There appears to be none. Does this exemplify the difficulty the ancients found in understanding fractions?

To show $\frac{9}{10}$ the Egyptians would have written in their notation

and that in our notation would be $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{10}$, $\frac{1}{20}$.

The Romans, too, thought in terms of the unit fraction. They used such names as *semis* for one-half, *triens* for one-third, *quadrans* for one-fourth, *sextans* for one-sixth. For such a frac-

tion as $\frac{3}{4}$ they used the term *dodrans* and the sign S==, the S of which signified one-half, and each horizontal line one-twelfth.

The Hindus gave us our numerals. They gave us also our two-numbered fractions. The manner of writing the fraction has had its vicissitudes: $\frac{5}{6}$, $\frac{5}{6}$, 5 sixths, $\frac{5}{6}$. The variations have been due to printing difficulties. Of course, as Roman numerals were in use in Europe until quite a late date, the first fractions of two numbers were written in the style

$$\frac{\mathrm{I}}{\mathrm{III}}, \quad \frac{\mathrm{V}}{\mathrm{VI}}, \quad \frac{\mathrm{XI}}{\mathrm{XXI}}.$$

Now that we have the background of the history of the invention of vulgar fractions let us turn to the teaching of them in the Primary School. Before entering into the details of method, two questions need our consideration. The first is, "What shall be the aim of our teaching?" and the second, "What difficulties of conception shall we encounter?"

Our Aim

Fractions can be simple, or they can be very involved. It is not our aim to instruct children so that they are able to deal successfully with such a complicated fraction as:

$$\frac{7\frac{1}{4} - 1\frac{1}{8} \times 3\frac{5}{9}}{15\frac{3}{11} \div 10\frac{8}{13}}.$$

Our aim in the Primary School is to give children a "grounding" in fractions, to ensure that they know what a fraction is, to make them capable of reading and interpreting a fraction, to enable them to use fractions as comprehendingly as they do the numbers of ordinary notation. We must set out to help them to state unhesitatingly that $\frac{7}{8}$ of a thing means that the thing is divided into 8 equal parts, and that something has been done, not with the whole thing, but with 7 only of those equal parts. Our aim will also include the teaching of the working of fractions of a simple nature in the four common processes.

Our Difficulties

We have already stated the conclusion that children understand "parts," that a piece may be "broken off" a thing, that a part may be taken from something. They know that a piece may be "broken off" a cake, a biscuit, a lump of cheese, a loaf of bread. That is the simple foundation of a fraction. Building upon that will create the difficulties. (*a*) Children do not realize easily more than one of any part. They glibly talk of one-quarter of a thing, they understand a verbal expression of a crude, unmeasured part, but the written fraction representing even one of a part seems to them something quite foreign. A fraction with a numerator greater than *one*, needs for them careful interpretation. (*b*) Instinctively they say that $\frac{1}{8}$ is greater than $\frac{1}{7}$, for eight is greater than seven. (*c*) When a multiplication sum with whole numbers is done, the answer must always be greater than either multiplier or multiplicand. When a multiplication with fractions is done, children expect the same "greater" result. (*d*) When doing addition or subtraction of fractions children automatically add or subtract numerators and denominators. (*e*) "Invert the divisor and multiply," the rule for division by a fraction, is a puzzle which to many children remains quite unsolvable.

Fraction Fundamentals

Children early become acquainted with the idea of parts, but that idea is very crude. It is loose and lacks exactness. It goes no farther than a naming of parts. It does not include a notion of the characteristics of parts. There must be a deliberate, planned, systematic study of those characteristics. What are they? It is essential that the teacher is conversant with them, and they are:

(*a*) A fraction expresses a relationship between two numbers or amounts. Such a relationship is implied in multiplication and division, for in multiplication there is a building up of parts into a whole, and in division a breaking up of a whole into parts. Thus, unconsciously the child from the first deals with fractions, stated not in the manner of the orthodox fractions.

(*b*) A fraction expresses the size of the parts and the number of the parts. The size is the denominator, the number is the numerator. These two ideas, expressed in the one statement, must be so thoroughly understood that fractions in the abstract may be fully comprehended. It is not sufficient that a child can draw a line $\frac{5}{8}$ of an inch long; he must realize that $\frac{5}{8}$ is as truly an amount as is 58.

(*c*) Equality in the size of parts and number of parts is implied in the fraction; $\frac{5}{16}$ means that something has been divided into 16 parts, but those parts are not haphazardly broken off. They are equal. Each is exactly $\frac{1}{16}$th of the thing divided. And the 5 parts that have been taken are also of equal size, the one to the other.

(*d*) Fractions have relative value one to another. They are isolated facts no more than are whole numbers. $\frac{3}{8}$ is as closely related to $\frac{3}{16}$ as is 12 to 6. Therefore, not only must the relationship between the two numbers of a fraction be known, but the relationship between different fractions must also be understood.

(*e*) Any number can be divided into any number of equal parts. There is no limit to the division.

(*f*) As the denominator increases, the size of each part decreases. If the denominator be doubled, the size of the part is halved.

(*g*) A fraction is an exact expression, more exact even than a whole number. For example, the term $\frac{5}{6}$ yd. contains not only the actual unit of measurement, the yard, and the derived unit, sixths of a yard, but also the definite number of those derived units, five. There are thus in the term $\frac{5}{6}$ yd. three expressed ideas. Therein is that which makes a fraction complex, and difficult to the child mind.

(*h*) If the numerator and denominator be multiplied or divided by the same number, the value is unaltered.

(*i*) The idea of division is inherent in fractions. It needs to be understood that $\frac{7}{8}$ of a shilling means $\frac{1}{8}$ of a shilling $\times$ 7, or 7 shillings $\div$ 8.

Those nine fundamentals have to be taught to the child before he can understand fully the meaning of fractions and before he can find ease in working them. Of course, they will not all be taught in the first lesson, nor in the first year. The realization of them will be gradual, but the progressively planned work will lead ultimately to their full comprehension.

General Method

The first work will be related to the child's unplanned acquaintance with

fractions. There will follow systematized *practical* exercises *with Plasticine*, cardboard, and other media. Then will be done written work dealing with fractions of concrete measures. Finally, exercises will call for the use of fractions in the abstract.

First Year

STEP 1. Fractions can be discussed even in the first year, that is, by children of 7+. Very early in our scheme of arithmetic, ruler work involving measuring in inches and halves of inches is introduced, and with the help of the ruler work, but without the use of the word "fractions," the idea of exact "parts" can have its commencing formulation.

STEP 2. During the process of measuring the child will become acquainted with the sign $\frac{1}{2}$. It will be used in connection with the measure of length. In the "mental" period a relation with other measures can be utilized. The children can be asked the price of $\frac{1}{2}$ lb. of butter, $\frac{1}{2}$ lb. of margarine, $\frac{1}{2}$ lb. of apples, $\frac{1}{2}$ a yard of ribbon, $\frac{1}{2}$ pt. of milk, and $\frac{1}{2}$ lb. of tea.

Correlated with this the child can *make a brick in Plasticine and cut it* into two halves, pastel $\frac{1}{2}$ an orange, cut out a strip of paper and divide it into two halves (after bending it equally), Plasticine a bun and cut it into two equal parts, and so on. With each exercise there should be written on the blackboard or by the child "$\frac{1}{2}$ an orange," "$\frac{1}{2}$ a cake," etc., that "$\frac{1}{2}$" may gradually become a commonplace, a matter of habit.

Later, when money sums are being done, the "$\frac{1}{2}$" will again occur as $\frac{1}{2}d.$ It will be sufficient if, in this first year, $\frac{1}{2}$ is the only fraction studied. $\frac{1}{4}d.$ and $\frac{3}{4}d.$ will be included in the money sums, but as they will not be used in any other way, it would be better for them to be left to the next year.

Second Year

In this year, in ruler work, children are engaged in dividing the inch into quarters and eighths. These fractions can be well studied in this period.

STEP 1. The first exercises in ruler work will be concerned with quarters. This work should be connected with $\frac{1}{4}d.$ and $\frac{3}{4}d.$ Thus will be gained the idea that an inch and a penny can each be divided into 4 equal parts. It is possible to draw one, two, three, or all of those parts. It is possible to count as coins, one of those parts, one, two, three, or four times. In each case 4 of the parts will make a whole.

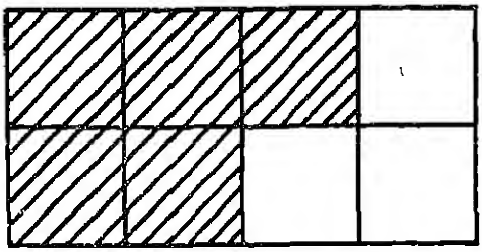
Further "mental" work, moulding of Plasticine, and drawing parts, similar to that of the first year, should be done.

After exercises in ruling quarters and halves, an introductory exercise in addition and subtraction of fractions can be attempted. Sums of this type should be set:

$\frac{1}{2}d. + \frac{1}{4}d. =$	$1\frac{1}{2}d. + \frac{1}{4}d. =$
$2\frac{1}{4}d. + \frac{3}{4}d. =$	$\frac{1}{2}d. - \frac{1}{4}d. =$
$2d. - 1\frac{1}{2}d. =$	$2\frac{3}{4}d. - 1\frac{1}{4}d. =$
$\frac{1}{2}$ in. + $\frac{1}{4}$ in =	$1\frac{1}{2}$ in. + $\frac{1}{4}$ in. =
$\frac{1}{2}$ in. − $\frac{1}{4}$ in. =	2 in. − $1\frac{1}{2}$ in. =
$2\frac{1}{4}$ in. + $\frac{3}{4}$ in. =	$2\frac{3}{4}$ in. − $1\frac{1}{4}$ in. =

STEP 2. The next ruler exercises introduce eighths On them fractional exercises, involving eighths should be devised.

First they should be of the practical concrete type as suggested with previous "parts" taught Then there should be the construction of rings or other shapes, and these should be

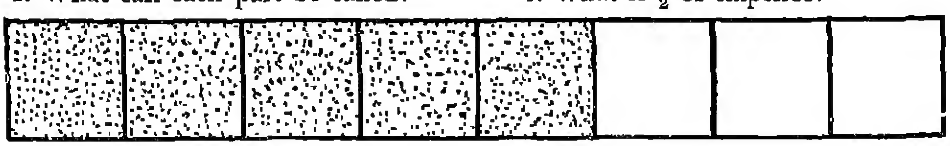


divided into 8 equal parts. The idea of equality should be stressed. On the blackboard draw an oblong 2 in. long by 1 in. wide. Divide it into 8 equal parts and shade 5 of them. Children then are asked questions similar to the following:

1. Into how many parts is the oblong divided?
2. What can each part be called?
3. How much of the oblong is shaded?

Then on the blackboard draw another oblong, 4 in. by $\frac{1}{2}$ in. Divide this also into 8 equal parts. Then ask these questions:

1. Into how many parts is this oblong divided?
2. What can each part be called?



3. What is the difference in size between one part of this oblong and one part of the first oblong?
4. How much of this oblong is dotted?
5. What is the difference in size between the parts dotted in this oblong and the parts shaded in the first oblong?

There should follow an exercise such as this:

$\frac{1}{8}+\frac{1}{8}=\frac{}{8}$ $\frac{1}{8}+\frac{2}{8}=\frac{}{8}$ $\frac{2}{8}+\frac{3}{8}=\frac{}{8}$
$\frac{3}{8}+\frac{3}{8}=\frac{}{8}$ $\frac{4}{8}+\frac{3}{8}=\frac{}{8}$ $\frac{4}{8}+\frac{4}{8}=\frac{}{8}$.

A further exercise of this style should follow. "Find the answers to the questions:

$\frac{16}{8}$ books = books.

$\frac{40}{8}$ pencils = pencils.

$\frac{80}{8}$ counters = counters.

$\frac{64}{8}$ marbles = marbles."

Interpret the first exercise as "Divide 16 books into 8 piles. How many in each pile?" and get children to interpret the others. They are already acquainted with $\frac{16}{8}$ as a division sum. The similarity of the above statements with the fractions in the previous exercise will lessen the pupils' usual nervousness when being introduced to something quite new.

STEP 3. A simple introduction to the multiplication of fractions can also be undertaken. Common everyday questions should be put, as:

1. What is $\frac{1}{2}$ of sixpence?
2. What is $\frac{1}{2}$ of threepence?
3. What is $\frac{1}{4}$ of two inches?
4. If I cut an orange into eighths, how many pieces shall I have.
5. If I gave Tom 3 of the pieces of the orange, what part of the orange would he have?

These questions could be followed by:

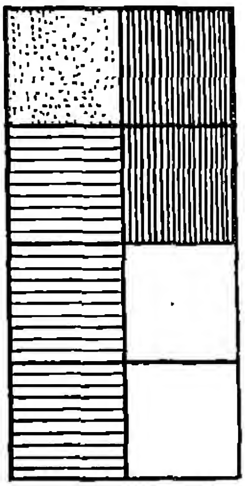
2 times $\frac{1}{4}$ =	4 times $\frac{1}{4}$ =	3 times $\frac{1}{4}$ =
2 times $\frac{1}{2}$ =	4 times $\frac{1}{2}$ =	5 times $\frac{1}{2}$ =
2 times $\frac{1}{8}$ =	4 times $\frac{1}{8}$ =	7 times $\frac{1}{8}$ =
$2 \times \frac{1}{4} =$	$4 \times \frac{1}{4} =$	$3 \times \frac{1}{4} =$
$2 \times \frac{1}{2} =$	$4 \times \frac{1}{2} =$	$5 \times \frac{1}{2} =$
$2 \times \frac{1}{8} =$	$4 \times \frac{1}{8} =$	$7 \times \frac{1}{8} =$

STEP 4. As revision of the work done, children could be tested with sums of which the following are specimens.

(*a*) Start with $\frac{1}{8}$ and add $\frac{1}{8}$ each time until you get to 2.

$\frac{1}{8}, \frac{2}{8}, \frac{3}{8}, \frac{4}{8}, \frac{5}{8}, \frac{6}{8}, \ldots$

(*b*)



1. Into how many parts is this shape divided?
2. What part of the shape is dotted?
3. What part is shaded with vertical lines?
4. What part is shaded with horizontal lines?
5. How much more is shaded with horizontal than with vertical lines?
6. What part is left clear?
7. How much more is covered with dots or shading than is left clear?

(*c*)

1. What is $\frac{1}{2}$ of 1*s.* 6d.?
2. What is $\frac{1}{8}$ of 1*s.*?
3. What is $\frac{3}{8}$ of 8*d.*?
4. What is $\frac{3}{8}$ of 1*s.*?
5. What is $\frac{1}{2}$ of £1?
6. What is $\frac{5}{8}$ of 1*s.*?
7. What is $\frac{1}{4}$ of £1?
8. What is $\frac{7}{8}$ of 1*s.*?
9. What is $\frac{1}{8}$ of £1?
10. What is $\frac{1}{4}$ of 6*d.*?

Third Year

The work of this year revises parts of an inch already practised, and adds to them the division of an inch into thirds, sixths, tenths, and twelfths. The sixths and twelfths logically follow thirds. The tenths will lead naturally to decimals, so they will be considered later in the chapter.

There should be no need to do the practical concrete work of the earlier years. Children by this time should be so familiar with fractions that their familiarity should breed contempt in the sense that no longer should they fear these double-figured intruders.

The ruler work in the new parts should follow the course of previous years: the drawing of lines, the cutting of parts from lines, the measuring of distances between dots, in all of which the new fractions should be practised.

Facts concerning fractions, other than their use as measuring values, are capable of being understood by children of this third year.

(*a*) Equality of fractions should be demonstrated in such a form as:

1 inch divided into 2 halves.
1 inch divided into 4 quarters
1 inch divided into 8 eighths.

The above should be drawn on the blackboard, and copied by the class. The lesson should proceed: "How long is the first line? How far is it along the first line from the first mark to the second? From the second mark to the third? Now think of the second line Into how many parts is it divided? What is each part? I am going along

the first line as far as the middle mark. How far is that? How far along the second line must I go to go the same distance? Then 2 quarters is the same as one-half. What is the same distance along the third line? It will be seen that $\frac{1}{2}=\frac{2}{4}=\frac{4}{8}$.

Children should answer questions on this discovery.

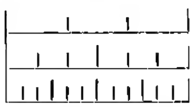
1. How many eighths in one quarter, in two quarters, in three quarters?

2. How many quarters in one-half?

3. Copy and fill in the spaces:

$$\frac{1}{4}=\frac{}{8} \qquad \frac{1}{2}=\frac{}{4}=\frac{}{8} \qquad \frac{3}{4}=\frac{}{8}$$

Similar work can be done using thirds, sixths, and twelfths.

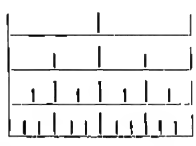


1 inch divided into 3 thirds.
1 inch divided into 6 sixths.
1 inch divided into 12 twelfths.

The class should be tested in exercises on the relation between these parts. They should copy and fill in:

$$\frac{1}{3}=\frac{}{6}=\frac{}{12} \qquad \frac{2}{3}=\frac{}{6}=\frac{}{12}$$
$$\frac{1}{6}=\frac{}{12} \quad \frac{3}{6}=\frac{}{12} \quad \frac{5}{6}=\frac{}{12}.$$

There should then be a combination of these facts.



1 inch divided into 2 halves.
1 inch divided into 4 quarters.
1 inch divided into 8 eighths.
1 inch divided into 12 twelfths.

Questions should be set on this diagram. Children should copy and fill in:

$$\frac{1}{2}=\frac{}{4}=\frac{}{8}=\frac{}{12} \quad \frac{1}{4}=\frac{}{8}=\frac{}{12} \quad \frac{3}{4}=\frac{}{8}=\frac{}{12}.$$

(*b*) *Improper Fractions and Mixed Numbers.*—Children should find no difficulty in learning the meanings of improper fractions and mixed numbers. The lesson should proceed: "Draw a line $1\frac{5}{6}$ inches long. You can say how long your line is in another way. You can say it is $\frac{11}{6}$ inches long. $\frac{11}{6}$ looks like a fraction, because it has two numbers and a dividing line between them. It is not really a fraction. Can you say why? Yes, a fraction is a part. $\frac{11}{6}$ is more than a part. It is a whole one and five parts more. It is not a fraction, so we call it an Improper one. Improper means 'not proper.'

"Change these to improper fractions:

$$1\tfrac{1}{2}=\frac{}{2} \qquad 2\tfrac{1}{8}=\frac{}{8} \qquad 1\tfrac{5}{12}=\frac{}{12} \qquad 2\tfrac{2}{3}=\frac{}{3}.$$

"The values you have changed to improper fractions are called Mixed Numbers. $1\frac{1}{2}$, $2\frac{1}{8}$, $1\frac{5}{12}$, $2\frac{2}{3}$ are all mixed numbers. That is a very sensible name for them. They *are* mixed: they each have a whole number and a fraction besides.

"Change these improper fractions to mixed numbers.

$$\frac{5}{2}= \qquad \frac{13}{4}= \qquad \frac{13}{6}= \qquad \frac{13}{8}= \qquad \frac{13}{12}= .\text{"}$$

(*c*) *Numerator and Denominator.*—For the teaching of these names the course of the lesson could be: "Write $\frac{3}{4}$ on the blackboard. Then ask questions. What have I written? How many numbers have I written? We have special names for each of those numbers, and you must know all about them. If I talk about $\frac{3}{4}$ of a penny, into how many parts have I divided the penny? If I talk about $\frac{3}{4}$ of an inch, into how many parts have I divided an inch? The 4 tells us what kind of parts there are. They are quarters. 4 is the

name of the parts, and it is called the Denominator, which is a long word meaning 'name.' How many of the quarters are there in $\frac{3}{4}$? The 3 is the number of the quarters. Its name is Numerator, which means 'number of'."

Emphasis on these names should be made by the use of other fractions such as $\frac{7}{8}$, $\frac{5}{6}$, $\frac{1}{12}$.

(*d*) *The Denominator.*—It is very necessary to get all children to realize the effect of increasing the denominator of a fraction. They must know that $\frac{1}{4}$ is less than $\frac{1}{2}$, $\frac{1}{3}$ than $\frac{1}{2}$, $\frac{1}{8}$ than $\frac{1}{7}$, $\frac{1}{20}$ than $\frac{1}{15}$, and so on.

Fourth Year

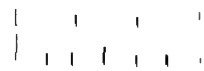
In this year the facts learned in previous years are co-ordinated to make a practical, understood introduction to the four processes.

Addition and Subtraction

The main point for children to be convinced of in these two processes is that more frequently than not fractions cannot be added or subtracted in the form in which they are presented. That is, they have to be changed to a common denominator.

The difficulty, and it *is* a difficulty to a child, may be overcome in this way. "Add 4 books to 6 sticks of chalk. What is the answer? You say 10. Then 10 what? 10 books? 10 sticks of chalk? Neither of those answers is right. We shall have to call the books and chalk by another name before we can add them together. We will say they make 10 articles. Add $\frac{1}{4}d.$ and $\frac{1}{2}d.$ What is the answer? It is $\frac{3}{4}d.$ What did you do to the $\frac{1}{2}d.$? Yes, you changed it to 2 farthings. You had to do so before you could add $\frac{1}{4}d.$ and $\frac{1}{2}d.$

"Now draw this:



1 inch divided into 3 thirds.
1 inch divided into 6 sixths

Add $\frac{1}{3}$ and $\frac{1}{6}$. If you look at both lines you will see that $\frac{1}{3}$ is equal to $\frac{2}{6}$, as $\frac{1}{2}d.$ was equal to 2 farthings. To add $\frac{1}{3}$ to $\frac{1}{6}$ we change $\frac{1}{3}$ to $\frac{2}{6}$. Now we can add $\frac{1}{3}$ to $\frac{1}{6}$ and make the answer $\frac{3}{6}$. Really we have changed the name or denominator of $\frac{1}{3}$ to sixths."

If the point is not realized, other fractions should be worked out in a practical way.

In this fourth year no large-numbered fractions should on any account be used. Even so, some children will at first be troubled when adding, say, $\frac{3}{4}$ to $\frac{2}{3}$. It will be seen that the new denominator is 12. To help the changing of the numerators children could set out the sum thus:

$$\frac{3}{4} + \frac{2}{3} = \frac{3\times3}{12} + \frac{2\times4}{12}.$$

This should be done only until the changing can be done with facility.

In dealing with fractions teachers should be careful not to confuse children by their choice of examples. The following is factual. A teacher introduced addition of fractions by using $\frac{1}{2}+\frac{1}{4}$. He asked his class what $\frac{1}{2}$ of 2 gallons was, and then what $\frac{1}{4}$ of 2 gallons was. Adding the answers received, the final answer was $1\frac{1}{2}$ gallons. Thus to the children $\frac{1}{2}+\frac{1}{4}$ was equal to $1\frac{1}{2}$. A most unfortunate choice of unit! Why did the teacher not use 1 gallon?

There are several methods of setting out the addition of fractions sums. Let us examine them.

(*a*) $2\frac{3}{8}+3\frac{4}{5}+1\frac{3}{10}$
$=6\frac{15}{40}+\frac{32}{40}+\frac{12}{40}$
$=6\frac{59}{40}$
$=7\frac{19}{40}$

(*b*) $2\frac{3}{8}+3\frac{4}{5}+1\frac{3}{10}$
$=6\frac{15+32+12}{40}$
$=6\frac{59}{40}$
$=7\frac{19}{40}$

(*c*) $2\frac{3}{8}+3\frac{4}{5}+1\frac{3}{10}$
$=6\frac{15}{40}+\frac{32}{40}+\frac{12}{40}$
$=6\frac{15+32+12}{40}$
$=6\frac{59}{40}$
$=7\frac{19}{40}$

In each case the whole numbers are sensibly dealt with first. Following that method (*a*), in my opinion, is to be preferred. The fractions when changed to a common denominator are shown separately. They retain their fractional character. If they are incorrect, the error can be readily seen and explained. In method (*b*) the fractional character is entirely lost in the second line. Method (*c*) combines (*a*) and (*b*) quite unnecessarily.

In working the fractions children should be taught to be methodical, to keep the equals vertically arranged line by line, to place the changed fractions exactly under the fractions of their origin.

In a combined addition and subtraction sum such as $2\frac{1}{5}-4\frac{1}{10}+2\frac{2}{5}$, it is of advantage to rewrite the sum, and to place the additions together, thus:

$$2\frac{1}{5}-4\frac{1}{10}+2\frac{3}{5}$$
to $$2\frac{1}{5}+2\frac{3}{5}-4\frac{1}{10}.$$

MULTIPLICATION

First the idea of changing a fraction to its simplest form is taught. Children know from their previous work that $\frac{2}{4}$ in. $=\frac{1}{2}$ in. It should be explained that if you divide both the numerator and the denominator of $\frac{2}{4}$ by 2, you obtain a simpler fraction, but of the same value. This division, called *cancelling*, should be practised in an exercise like, "Cancel these fractions or make these fractions simpler by dividing both numerator and denominator by the same number:

$\frac{9}{12}=\quad \frac{4}{6}=\quad \frac{6}{8}=\quad \frac{7}{14}=\quad \frac{11}{22}=.$"

This work should be continued in the cancelling of more extensive expressions, as: $\frac{5\times3}{15\times8}\quad\frac{2\times7}{4\times14}\quad\frac{10\times3\times12}{18\times20\times14}.$ This will lead to the idea of cancelling instead of multiplying completely the numerators and then the denominators, and simplifying afterwards.

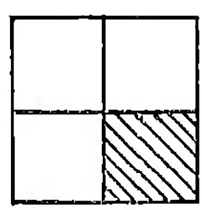
The process of multiplication should be done first by multiplying a fraction by a whole number and a whole number by a fraction, and then a fraction by a fraction. It is advisable in the early exercises to use not the sign "×" but the word "of." Start with such an exercise as: $\frac{1}{2}$ of $4=\quad\frac{1}{4}$ of $12=\quad\frac{1}{3}$ of $12=\quad\frac{1}{3}$ of $9=\quad$. Then, aided by a ruler, the children could do:
$\frac{1}{2}$ of $\frac{1}{2}$ in. $=\quad\frac{1}{2}$ of $\frac{1}{4}$ in $=\quad\frac{1}{2}$ of $\frac{1}{3}$ in. $=$.

In due course the sign "×" must be shown to have the same significance as "of." It may be done in this way:

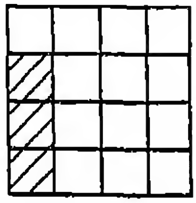
As 4 lengths of 6 in. $=4\times6$ in., so
4 lengths of $\frac{1}{2}$ in. $=4\times\frac{1}{2}$ in.
As 6 bags of 2 lb. each $=6\times2$ lb., so
6 bags of $\frac{1}{4}$ lb. each $=6\times\frac{1}{4}$ lb.

Children have found $\frac{1}{2}$ of $\frac{1}{2}$ in., and the next step will be to demonstrate that $\frac{1}{2}$ of $\frac{1}{2}$ or $\frac{1}{2}\times\frac{1}{2}=\frac{1}{4}$, whatever be the units employed.

(*a*)
$\frac{1}{2}$ of $\frac{1}{2}=\frac{1}{4}$



(b)
$\frac{3}{4}\times\frac{1}{4}=\frac{3}{16}$



The method will be: "Draw a 1-in. square. Divide it into 2 equal parts. What is the size of each part? Our sum says we have to take a half of this. Then divide the $\frac{1}{2}$ into 2 equal parts. Shade one of the parts. What part of all the square is the shaded piece? So $\frac{1}{2}\times\frac{1}{2}$ is $\frac{1}{4}$. *Let us think of doing the sum in* this way. $\frac{1}{2}$ of $\frac{1}{2}$ or $\frac{1}{2}\times\frac{1}{2}$ is a multiplication sum. Multiply the numerators together: $1\times 1=1$. Now multiply the denominators: $2\times 2=4$. Then the answer is one over 4 or $\frac{1}{4}$. That is the answer we found by doing our drawing."

Fractions of more difficulty should be demonstrated. Such might be $\frac{3}{4}$ of $\frac{1}{4}$. The method in connection with the drawing (*b*) above should be: "Draw *again a 1-in square. Divide it into* 4 equal parts. What will each part be? You have to find $\frac{3}{4}$ of each part. Divide each part then into 4 parts, and shade 3 of these small parts. Now into how many parts is the whole square divided? How many parts are shaded? Then $\frac{3}{4}\times\frac{1}{4}=\frac{3}{16}$. Is that true? Multiply as you did before: $3\times 1=3$, and $4\times 4=16$. The answer is 3 over 16. Do the answers agree?"

Children by their own efforts should demonstrate by drawing in a suitable square or oblong that $\frac{1}{4}\times\frac{1}{2}=\frac{1}{8}$, $\frac{3}{4}$ of $\frac{1}{2}=\frac{3}{8}$, $\frac{1}{2}\times\frac{1}{3}=\frac{1}{6}$.

The next step will be to multiply more complicated fractions to prepare for proportion, area, and such types of sums where procedure by fractional methods simplifies working. In these sums it must be emphasized that mixed numbers have to be changed to improper fractions.

$$1\tfrac{7}{11}\times 2\tfrac{4}{9} = \frac{\overset{2}{\cancel{18}}}{\underset{1}{\cancel{11}}}\times\frac{\overset{2}{\cancel{22}}}{\underset{1}{\cancel{9}}} = 4$$

$$2\tfrac{1}{2}\times 1\tfrac{1}{10} = \frac{\overset{1}{\cancel{5}}}{2}\times\frac{11}{\underset{2}{\cancel{10}}} = \tfrac{11}{4} \text{ or } 2\tfrac{3}{4}$$

$$1\tfrac{1}{8}\times 5\tfrac{1}{3} = \frac{\overset{3}{\cancel{9}}}{\underset{1}{\cancel{8}}}\times\frac{\overset{2}{\cancel{16}}}{\underset{1}{\cancel{3}}} = 6$$

This should be contrasted with the procedure in addition and subtraction sums where the whole numbers receive *attention first.*

Division

Probably division of fractions is the most difficult of all processes for the teacher to teach, and for the children to learn, that is, if the children really know what they are doing.

The work should be introduced by concrete examples.

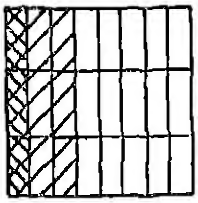
1. Divide 1 in. into $\frac{1}{4}$ in. How many parts? Written down that is $1\div\frac{1}{4}=4$.
2. Divide 1 lb. into $\frac{1}{2}$ lb. How many halves? Written down it is $1\div\frac{1}{2}=2$.
3. Divide 1 lb. into $\frac{1}{4}$ lb. How many quarters? Written down it is $1\div\frac{1}{4}=4$.
4. Divide 2 lb. into $\frac{1}{4}$ lb. How many quarters? Written down it is $2\div\frac{1}{4}=8$.
5. Divide 3 in. into $\frac{1}{8}$ in. How many eighths? Written down it is $3\div\frac{1}{8}=24$.

Draw a line 3 inches long and divide it into eighths. By counting the eighths this answer can be shown to be correct.

All the above and more should be done. It should be made impossible for the child not to understand the process. Then should follow the question, "How is it possible from $3\div\frac{1}{8}$ to get the answer 24?" and the answer is, "Invert the divisor and multiply":

$$3\times\frac{8}{1}=24.$$

The more difficult type of fraction $\frac{3}{8}\div 3$ should next be tackled.



The method should be: "Draw an inch square and divide it vertically into 8 parts. Shade $\frac{3}{8}$ of the square. Then divide the $\frac{3}{8}$ into 3 parts and shade in another way. It will be seen to be $\frac{1}{8}$ of all the square."

$$\frac{3}{8}\div\frac{3}{1}=\frac{\overset{1}{\cancel{3}}}{8}\times\frac{1}{\underset{1}{\cancel{3}}}=\frac{1}{8}$$

It should be pointed out that putting 1 under a number to form a fraction is often useful, and does not alter the value of the numerator of the fraction.

Following this exercise should be a number of the type $\frac{3}{8}\div\frac{3}{16}$. The next exercises will introduce mixed numbers. It must be emphasized that, as with multiplication, mixed numbers must always be changed to improper fractions.

Decimals: Third Year

The idea of decimals should be introduced by the division of inches into tenths. Having made a ruler showing tenths, and drawn and measured lines of inches and tenths, children should be shown what decimals mean. $1\frac{2}{10}$ in. can be written in another way as 1·2 in. In 1·2 there is a whole number and a fraction. They are divided by a dot, called a decimal point. Similar numbers are 1·8 in., 2·3 in., 3·5 in., 4·9 in. In each case the figure to the right of the dot is a fraction and is a number of tenths.

Various shapes—squares, oblongs, and triangles—including in their sides tenths of inches written as decimals should be drawn.

Then exercises of a concrete type should be set, as:

·1 of 10*d.*=	·2 of 3 yd. 1 ft.=
·1 *of 1s. 8d.*=	·6 *of 10s.*=

Fourth Year

Work similar to that of the third year should be continued. To it should be added the fact that ·01 is one hundredth, and the value of place in numbers.

Th.	H.	T.	U.	Tenths.	Hundredths.
1	2	7	8	3	5

There should be change of decimals to vulgar fractions and vice versa.

It is suggested in the scheme that addition and subtraction be the only processes of decimals taught in the Primary School. It must be impressed on children that in each of these processes decimal points must be vertically beneath one another: in other words, place values have to be carefully noticed.

If the multiplication of decimals is attempted, the easiest method to use is that in which the multiplicand and the multiplier are treated as normal numbers, and then to find the number of decimal places in the product by counting them up in the two numbers multiplied together. Thus:

$$\begin{array}{r}
186{\cdot}15\\
23{\cdot}7\\
\hline
3723000\\
558450\\
130305\\
\hline
4411{\cdot}755\\
\hline
\end{array}$$

Other methods can be taught, such as *the standard form method*. The process consists in converting the multiplier into a quantity consisting of a whole number of one digit followed by decimal places, and in adjusting the other quantity accordingly, e.g. $22{\cdot}42 \times 35{\cdot}2$. Put $35{\cdot}2$ in standard form thus: $35{\cdot}2 \div 10 = 3{\cdot}52$; but this will make the answer 10 times smaller. To correct this, multiply the other number by 10, thus $22{\cdot}42 \times 10 = 224{\cdot}2$. Then multiply

$$\begin{array}{r} 224{\cdot}2 \\ 3{\cdot}22 \\ \hline 672{\cdot}6 \\ 44{\cdot}84 \\ 4{\cdot}484 \\ \hline 721{\cdot}924 \end{array}$$

The advantage of this method is that the first line gives the approximate answer. Multiplying by ·2 is multiplying by 2 and dividing by 10; by ·02 multiplying by 2 and dividing by 100; hence the figures of the answer are moved one or two places *to the right*.

If division of decimals is taught, the best method I find is the following. Suppose the sum to be $175{\cdot}44 \div 6{\cdot}8$. Write the sum as a fraction. Turn the divisor into a whole number by multiplying by 10, and treat the dividend in *the same way*. Then divide as in long division. The set out of the sum would be:

$$\frac{175{\cdot}44}{6{\cdot}8} = \frac{1754{\cdot}4}{68} \qquad \begin{array}{r} 25{\cdot}8 \\ 68\overline{)\,1754{\cdot}4} \\ 136 \\ \hline 394 \\ 340 \\ \hline 544 \\ 544 \end{array}$$

PERCENTAGES

Little beyond an introduction will be done in the fourth year in the matter of percentages. It should be shown that (*a*) a percentage is a fraction, (*b*) it is a fraction in which the denominator is always 100, and (*c*) the 100 is written %.

The first step will be to show that 50% is $\frac{50}{100}$, 1% is $\frac{1}{100}$, 40% is $\frac{40}{100}$ and so on.

Then should be found the connection between the three types of fractions, using such simple examples as:

$$5\% = \tfrac{5}{100} = {\cdot}05 \quad 30\% = \tfrac{30}{100} = {\cdot}3\,.$$

Very simple concrete examples may then be given; for instance, what percentage is *6d. of 1s. 0d.*? 9 in. of 1 yard? 10 cwt. of 1 ton?

In all the four years of the Primary School the numbers used in fractions, whether vulgar, decimal, or percentage, *should be kept within sensible bounds*. The more of them that come within the experience of the children the better. The main object of the work is to get the children used to the idea of fractions: the extended use of them is for the Secondary School.

CHAPTER FIFTEEN

MEASURES

THERE are seven main types of weights and measures with which children in the Primary School have to become acquainted. They concern money, long measure (length), square measure (area), cubic measure (volume), weight, capacity, and time. Much that is redundant has been taught in the past; quite an amount that is unnecessary clings to the present. At a recent external entrance examination, in the arithmetic paper, one area sum concerned a measurement in "roods" Of what use was such a sum? Who today uses roods? What antiquarian was it who could have set such a sum? We had hoped we were living in enlightened educational days.

The only tables necessary for our present-day Primary School curriculum are the following. They are stated here at the outset of this chapter so that there can be no doubt what the scope of the chapter is.

Money.

4 farthings = 1*d*.
12 pence = 1*s*.
20 shillings = £1

Length.

12 in. = 1 ft.
3 ft. = 1 yd.
22 yd. = 1 chain.
10 ch. = 1 furlong.
8 fur. = 1 mile.
1,760 yd. = 1 mile.

Area.

144 sq. in. = 1 sq. ft.
9 sq. ft. = 1 sq. yd.
484 sq. yd. = 1 sq. ch.
10 sq. ch. = 1 acre.
640 acres = 1 sq. mile.

Volume.

1,728 cub. in. = 1 cub. ft.
27 cub. ft. = 1 cub. yd.

Weight.

16 oz. = 1 lb.
14 lb. = 1 stone.
28 lb. = 1 qr.
4 qr. = 1 cwt.
20 cwt. = 1 ton.

Capacity.

2 pints = 1 quart.
4 quarts = 1 gallon.
2 gal. = 1 peck.
4 pk. = 1 bushel.
8 bus. = 1 quarter.

Time.

60 sec. = 1 min.
60 min. = 1 hour.
24 hrs. = 1 day.
7 dys. = 1 week.
365 or 366 days = 1 year.

Other measures and units of measures as far as the Primary School is concerned should be relegated to the waste-paper basket, or perhaps much farther!

The four common processes and fractions having been experienced, their

correct application to these weights and measures depends only on a knowledge of the relations between the various units of each of the weights and measures tables. These tables must be learned; then should the pupils be able to tackle without difficulty the working in those weights and measures of problems needing the manipulation of the four processes.

Let us consider the measures in the order listed in the first paragraph. With the table of money we have already dealt.

Long Measure

First Year

The smallest unit, inches, will be introduced in the first year, not as a part of the table of long measure, but as a convenient length for ruler work. Incidentally, it may be found to be a defined part of a twelve-inch ruler. The ruler may be indicated to be a foot long, but nothing formal in this year in these units should be expected.

Second Year

In the second year, as outlined in Chapter XIII, practical work in the use of parts of inches is continued. The scheme of this new year embraces money sums in the four common processes. In the use of those processes it has to be known that 12 pence make 1 shilling. 12 inches also make 1 foot, which fact can be learnt by observation of a 12-inch ruler. The similarity between 12*d.*=1*s.* and 12 in.=1 ft. makes working in the four processes in the latter units a simple matter.

It may be of interest to scholars to measure the lengths of the two parts of their thumbs and to compare them with the length of an inch. The name inch is derived from the Latin *uncia*, meaning a thumb-joint. The natural *foot* formed the basis of the unit in long measure. Of course it was variable in length, and was shorter than the standard foot in use today. The average length of a man's foot is about 10 inches.

Third Year

In this year the unit of a yard is added to the measure. It should be connected with practical things first: the purchase of yards of material, a man's "striding" pace, the distance from an adult's chin to the finger-tip of a well-stretched arm. In olden times the "yard" varied considerably. It became necessary to have a standard unit, and the story is told that King Edward III's arm was measured for the purpose. Comparison might be made with the French child's similar measure, the metre, which is a little longer than the yard, and which is the length of a clock's pendulum which swings once per second.

Interest in the yard can be gained by making exercises centre around a rounders base and other games' pitches, by measuring lengths of school walls, by measuring distances covered in physical-training activities Exercises in the three units using the four simple rules should be done.

Fourth Year

The rest of the table will be learnt in the fourth year. Chains, furlongs, and miles are the units to be added: poles are omitted as unprofitable. The chain is the length of a cricket pitch, and the surveyor's metal measuring instrument. The furlong, as already pointed out, was the distance oxen

could draw a plough before they required a rest. This distance was about one-eighth of a mile. The mile itself is a relic of Roman days. The Latin *mille passus* signified 1,000 paces, and a pace consisted of two steps, measuring together about $1\frac{3}{4}$ yards. Thus the distance of a mille or mile was $1{,}000 \times 1\frac{3}{4}$ yd. $= 1{,}750$ yds. Very sensibly this was added to, so that a mile contains 1,760 yards, a number which is capable of being divided exactly into halves, quarters, eighths, and other simple parts.

The four compound rules will be done in connection with the complete table, not all included in the same sum, for it is not reasonable to suppose that a length measured in miles would require exactness to one inch. The various units should be connected with children's activities in the playground and on the sports' field, the longer distances with car, train, and bus journeys and with map reading.

The whole of the work should have a practical aspect.

Area: Square Measure

Great care must be exercised in the introduction of this part of the work. It is quite useless to tell children that by multiplying length by breadth you obtain an area. In the first place they will not understand of what you are speaking. In the second place, until the formula is comprehended, the statement is sheer rubbish. Neither you nor anyone else can multiply a distance by another distance. (The formula length $\times$ breadth $=$ area is introduced later, only when children understand what area means.) The statement 5 in. $\times$ 3 in. is absurd. You cannot multiply inches by inches, any more than you can multiply one sum of money by another sum of money, even though a member of a B.B.C. Brains Trust averred that he had been set such a sum when at school.

Second Year

In this year squares and oblongs are drawn as exercises in ruler work and measurement. No mention of "area" in connection with them is made.

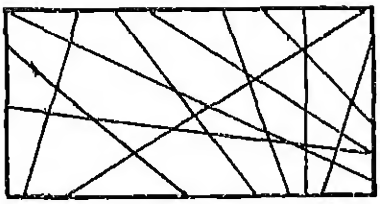
Third Year

In the third year this knowledge of the manner of drawing rectangles is used as a basis for the introduction of the idea of "area." It is in this introduction that care must be taken to give a clear indication what "area" really is.

The first lesson should proceed on these lines. "Cut out in gummed paper an inch square. Do it exactly. Now stick it in your exercise book. I want you to notice that you have covered a part of your page. Now cut out a second inch square. Stick that in your book. Again you have covered over a piece of your page. Cut out one more inch square. Stick that in your book. What have you done this time?" It is probable the answer will be given that a piece of the page has been covered over. That is the purpose of the repetition. No mention has been made of "area," but the idea of a covered space will be in process of formation.

A second lesson should follow in this way. "Draw an oblong in your book 2 in. long and 1 in. wide. I am going to do the same on the blackboard. Now I want to measure how much of my board is inside that oblong. I usually measure with a ruler. Will someone measure with my ruler how much of my board is inside my

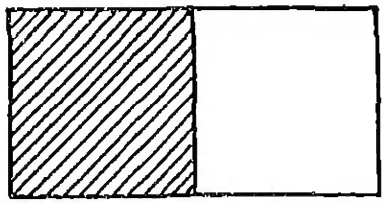
oblong?" If a child attempts to measure the area of the oblong, lines should be drawn wherever he puts the ruler. Something like this may result:



It will be seen that the space can *not* be measured with a ruler. All this may take up a deal of time; it will be time well spent. The lesson should proceed: "Can you tell me how to find out the space of my blackboard inside my oblong? No! (*probably*). Well, *you* cut out another 1-inch square of gummed paper. Can you fit it in your oblong? How many squares do you need to fill your oblong? Two! Then how much of your page is inside your oblong? '2 squares' is correct."

Repetition of this work should be done with squares and oblongs of other sizes (not including fractions of inches), and in each case the class should discover how many "squares" are needed to cover the areas. The rectangles might with advantage be filled up with inch squares cut from gummed paper.

It is necessary now, after that preliminary work, to use the word "area" and to prove how the size of that area is obtained. Let the lesson proceed in this way. "Draw an oblong 3 in. long and 2 in. wide. Divide it into 1-inch squares. How many squares are there in the top row? How many squares in the bottom row? How many together? Now draw a 1-inch square, and cut it out. How many times can you fit your square along the top row of your oblong? How many times along the second row? How many together?" Explain that it is required to find how much of the exercise book is covered



by the oblong. A line can be measured with a ruler. The amount of the page covered by the oblong cannot. That space is measured by using the inch square. So in the exercise just done the space covered is 6 square inches.

Repeat the exercise with an oblong 4 in. by 2 in. It will be discovered that there are four squares along the top row, and four also along the second row. Children should be told that the space covered is called an "area," and they will probably by this time realize that

Area of oblong = area of one row × number of rows.

So the area of the oblong just drawn will be 4 sq. in. × 2 = 8 sq. in.

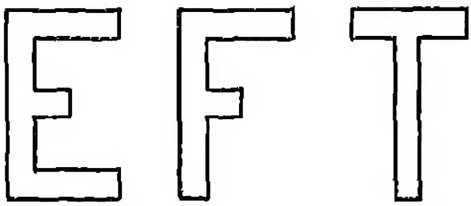
Similar work should be done with an oblong 5 in. by 3 in., and it will be seen that its area is 5 sq. in × 3

Thus area should be introduced not as a process of length × breadth, but of the area of a row of unit squares × the number of rows of those unit squares.

Other areas can well be found. of the cover of an exercise book, a door mat, a piece of cardboard, and similar available objects.

Larger objects involving the use of square feet and square yards should be considered, but it would be inadvisable

to introduce at this stage the reduction from one unit to another. Areas that could be used are the blackboard, the floor of the classroom, the top of a table, a football or other games pitch. Letters might be cut from cardboard and the area of cardboard necessary for their cutting-out worked out.



FOURTH YEAR

In this year should be introduced the shortened form of statement. The length gives the number of unit squares along the top row of an oblong, the breadth the number of rows, therefore the statement may be shortened to area=length × breadth, or area $= l \times b$, and from that can be determined that

$$\frac{\text{area}}{b} = l \text{ and } \frac{\text{area}}{l} = b.$$

So that if an oblong is 5 in. by 3 in., the sum becomes

$$\begin{aligned} \text{area} &= l \times b \\ &= \bar{5} \times \bar{3} \text{ sq. in.} \\ &= 15 \text{ sq. in.} \end{aligned}$$

The connection between the units of square measure should be learnt and used in the finding of areas of playground, of the garden, of a recreation ground, of the walls of a room (by continued oblongs), of shapes within shapes as the red cross on a St. George's flag. Such areas should be worked out in this way. "In a room 18 ft. by 15 ft. is a carpet 15 ft. by 12 ft. How much of the floor is not covered by the carpet?"

$$\begin{aligned} \text{Area of room} &= 18 \times 15 \text{ sq. ft.} \\ &= 270 \text{ sq. ft.} \\ \text{Area of carpet} &= 15 \times 12 \text{ sq. ft.} \\ &= 180 \text{ sq. ft.} \end{aligned}$$

Area of floor not covered $= 270 - 180$ sq. ft. $= 90$ sq. ft.

Finally the area of an irregular figure should be found. Such a figure should be drawn on squared paper, and the number of completely covered squares counted. To these should be added squares more than a half covered, while those less than half covered should be disregarded.

Cubic Measure: Volume

An area covers a space. A volume fills a space. This idea should be introduced in the fourth year, but the work should be of the simplest, and include cubic inches, feet, and yards. It should also be mentioned that the volumes of liquids are found by measuring in pints, etc., and the connection between a cubic foot of water and a gallon found.

It should be shown that a match-box, a chalk-box, a pen-box, an aquarium, a brick, a box containing cottons (borrowed from the needle-work class) each fills a space. Therefore each has a volume. A volume has three dimensions: length, breadth, and depth. The three dimensions of each of the articles mentioned should be measured and tabulated.

Cardboard boxes and Plasticine bricks should be constructed. Using one of one cubic inch, the volume of various cuboids should be calculated. It will be found that in the bottom

layer of a block there are so many cubic inches (ft. or yd.), and the depth will give the number of such layers. The method of calculation should be built up on the lines used in the teaching of area. It should be proved in a practical manner.

Weight

Children will have experienced weight at quite an early age. They will have considered a thing heavy or light. They will have said, or heard their parents say of them, that they had gained or lost in weight. They will have been *told*, "You must walk like a good fellow. You are too heavy to carry now." They will know some things are so heavy that they could not lift them, but that the lifting must be left to an adult.

Second Year

In these days of mechanical weighing apparatus children will not have experienced the weights of pounds and ounces. They go into the confectioner's or the butcher's shop and see a cylinder turn or a hand move quite magically, but what the connection is between the sweets or the piece of meat and the weight and the machine they cannot see. It is not logical to ask them to work sums concerning pounds and ounces, if they do not recognize the weights of pounds and ounces. In the second year a practical acquaintance with these two weights should be arranged. Children should weigh sand in bags, using 1 lb., $\frac{1}{2}$ lb., $\frac{1}{4}$ lb., and oz. weights. They should be encouraged to guess the weight of various small articles in the room, then weigh them and compare their guess with the correct weight. The idea of the work here is not to teach the "weights" table but to ensure a knowledge of what a pound and an ounce really are.

Third Year

In the third year the extra weight to be considered is the stone. The practical connection will be the child's own weight, and the introduction of this new weight can be made when there is a medical inspection.

Simple experiments in the four rules of using weights of adults and of children, of vegetables and of fruits should be done.

Fourth Year

The other units of the table—tons, hundredweights, and quarters—are included in the fourth-year scheme. Again, a practical approach is possible by way of the coalman and his load of a ton divided into twenty sacks of a hundredweight. Reference to this practical work has been made in an earlier chapter.

The hundredweight perhaps needs a little explanation. Why 100-weight if there are 112 lb. in the unit? Originally a hundredweight was a 100-weight, that is, it was 100 lb., but there was an allowance of extra pounds to ensure full weight. A baker's dozen is similarly 13. During Queen Elizabeth's reign our present unit of 112 lb. was fixed.

No difficulty should be met in the manipulation of the four rules: they follow closely the methods taught when dealing with money sums.

Capacity

While some commodities are sold by the measure we have just considered, others cannot be so sold. The milk-

man would find it difficult to make sales if he had to weigh his milk. He could do so, but the system would be extremely complicated. Therefore there is in use a set of measures involving standard-sized vessels into which commodities can be poured. Such commodities are mainly liquids, grain, and fruit.

First Year

Without talking of "capacity," children should experiment with measures of capacity. They require school milk-bottles, jugs, large cups, tumblers, pails, and kettles. From them they will learn that pints and quarts can be measured, that two pints make one quart, that three school milk-bottles are necessary to measure one pint, that a large cup or tumbler measures half a pint, that jugs hold $\frac{1}{2}$ pint, 1 pint, or 1 quart, that a pail or kettle holds a number of pints or quarts. In this practical way children will acquire exact knowledge of the first two units of the measure of capacity.

The making of cut-outs of jugs, cups, etc., in scaled sizes comparable with the measures they hold will impress this knowledge on the minds of the pupils.

Second Year

No new units are introduced in this year, but those learnt in the first year may be usefully used as items in shopping sums.

Third Year

Practical work in this year should introduce the measure of the gallon. The four simple rules should be done mainly in connection with the milkman. This tradesman sells his milk in quarts and pints, but he does not buy in that way. He purchases it by using a larger unit, namely, the gallon.

In this class children can appreciate the need for this measure of capacity, and the facts stated at the beginning of this section should be given them. It could also be explained that the name of this measure, "capacity," signifies the power of holding. It answers the questions, "How much does this vessel hold? What amount can we get into it? How much of a certain substance can be poured into it?"

Fourth Year

Apples, wheat, and other grains, flour, petrol, vinegar, and milk are measured by the units of capacity. The first of these need a knowledge of pecks, bushels, and quarters. A visit to a greengrocer's shop would help children in the conception of the larger measures.

Then should be done exercises involving the four processes.

There should also be taught the relation between the volume and the weight of water. This could be done by an exercise on the filling of the school aquarium. What weight of water is needed to fill it when it is cleaned out? Or the weight of water carried in a full pail might be ascertained.

Time

Children are very proud when they are able to tell the time. The work in this measure should therefore be started in the first year.

First Year

Cardboard clock faces and hands should be cut out, the hands being then pivoted by means of paper-fasteners.

First the numbers of the hours 1 to 12 should be marked. Children should learn, by moving the small hand, how to read what hour of the day it is. The minute marks should then be added, and the reading of the long hand will follow.

It should be noticed that the hour hand moves more slowly than the long one, but it does move. Thus at so many minutes past an hour the small hand has journeyed between two hour marks. This complication must be realized in order that correct time may be read. The difference "past the hour" and "to the hour" must be explained.

Formal sums in the first year should not be done. Clock faces should be drawn showing various times of the day, such as 4 o'clock, 15 minutes past 8, 20 minutes to 6. The clocks could show the answers to questions like, "At what time do you come to school in the morning?—in the afternoon? At what time do you go home in the morning?—in the afternoon? At what time do you leave home in the morning? At what time do you reach home in the afternoon?"

The only parts of the time-table to be taught concern hours and minutes with their relationship—60 minutes make one hour.

Second Year

This year entails further exercises in the reading of the clock face. Children also are taught that clocks do not always keep correct time; they may be fast or slow. Pupils are given the knowledge of the meanings of a.m., noon, p.m., and midnight.

Third Year

Time is in practical use in time-tables, the reading of which in our mechanical age is often a necessity. Interesting exercises can be set on the reading of time-tables of local rail and bus services. It is suggested that the time-tables used are of local routes to accord with the children's experiences, and the times and distances concerned will be of reasonable dimensions.

Fourth Year

In this year the full table of time measure, from the "second" to the "year," is taught. Examples in the four processes will be set. In compiling sums on the number of days in a period, great care must be taken to state exactly whether the days named are included in or excluded from the period to be measured.

Further exercises in rail journeys of a distance longer than that of the third year will be included in the work. These, and voyages and aeroplane flights, may well be done in correlation with geography, as a means of gaining acquaintance with countries of the world and their relative distances from one another.

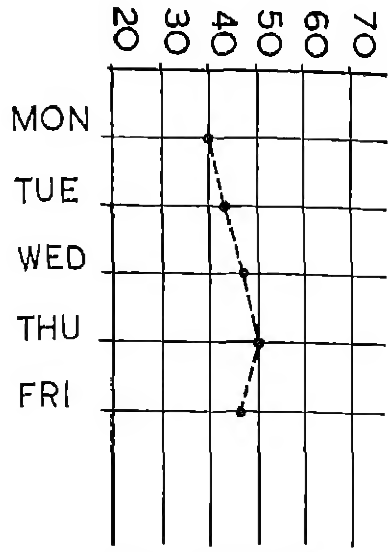
Much further work can be done with this measure in connection with geography. Greenwich Mean Time and the variations of times in different countries should not be omitted. It should be noted that the movement of the moon round the earth roughly gives us our months, that the rotation of the earth on its axis produces our day, and that the year is the result of the earth revolving round the sun. In this connection should be treated the facts concerning leap years.

There is a calendar year and a solar year. The former consists of 365 or 366 days, and the latter almost $365\frac{1}{4}$ days. To allow for this $\frac{1}{4}$ day, we have

leap years. These are the years in which the number of the year is exactly divisible by 4. But the addition of a day every fourth year, because the solar year is not quite $365\frac{1}{4}$ days, has to be corrected. Leap year does not occur in the years in which the number of the year ends in 00 unless it is exactly divisible by 400. Thus 1900 was not a leap year, 2000 will be, 2100 will not be. Reckoning in this way, there will be an error of 1 day only in something like 3,320 years!

Although not a part of the measure of time, most usefully there could be made graphs of the daily reading of room and out-of-door temperatures and of daily attendance of the children. There will be practical connection with days of the week and months of the year and of the measure of time. The children of the fourth year should readily grasp the essentials of a graph: two related units and two graded scales

These graphs would be useful to the geography and nature-study teachers; they would be a means of teaching how to construct a graph, and of collecting and conserving information relative to the seasons of the year.



INDOOR TEMPERATURES
9 A.M.
MARCH 24 TO 28, 1947.

CHAPTER SIXTEEN

REVISING AND TESTING ARITHMETIC

SOME theorists and teachers of arithmetic are strongly of the opinion that the subject should be taught by the "topical" method. One topic, they say, should be completely and fully taught before the next topic is introduced. I have to disagree very fervently. Arithmetic is not composed of isolated topics. Arithmetic is a whole consisting of parts closely related and intertwined. Those parts all deal with numbers, but from slightly differing aspects. Areas and volumes cannot be thought of as divorced from each other or from ruler work. The measure of time is closely linked with that of distance. Money is connected with all the measures: it is necessary for the purchase of tons, cwts., etc., of gals., qts., pts., of yds., ft., ins., and is received for hours of work. Fractions enter into every section of the subject. Therefore how can arithmetic be possibly taught as "topics"?

That brings us to the subject of a part of this chapter, namely, "revising arithmetic." It is necessary to test the progress of children at the end of each term. But revision should not be left to the period immediately prior to the examination. It should be conducted throughout the whole of the term. In fact, in a carefully thought-out scheme a good proportion of the work and exercises will so connect the work in hand with that done previously that there will be no chance of forgetting what has gone before. Revision will perforce be continuous.

One kind of revision can be by the use of the narrative type of sum. This example is suited to a fourth-year class.

1. A coalman sold 18 tons of coal each day for six days of a week. If he was paid 3*s.* 9*d.* a cwt., how much did he take in the six days?

2. If the cost of the coal and other expenses was $\frac{3}{4}$ of his takings, how much profit did he make in a week?

3. Suppose he had the same amount of profit each week, and he took a fortnight's holiday in the year, how much short of £1,000 were his profits for the year?

4. For his holiday he went to a place 275 miles from his home. He paid one guinea each day at the hotel at which he stayed. To the hotel he went by car, which did 22 miles to a gallon of petrol, and petrol cost him 2*s.* 0*d.* a gallon. He spent £7 10*s.* on amusements. How much altogether did his fortnight's holiday cost him?

In the above four sums are revised addition, subtraction, multiplication, fractions, and the tables of money, weight, and time.

Another form of revision suitable to any stage is the following. This example could be set in the third year.

Line A.	1463.	1. Add lines A, B, and C.
Line B.	2139	2. Take line A from line D.
Line C.	756	3. Multiply line C by 8.
Line D.	3045	4. Divide line D by 9.
		5. Add lines B, C, and D.
		6. Add lines A and C, and take the answer from line D.
		7. Add lines A and D, and divide the answer by 7.
		8. Multiply line A by 4.

A third and interesting form of revision suitable for all classes is shown on the right. The example is for a second-year class.

The children are told that they must start at the bottom of the ladder and work upwards, the test being how far they can go up without a fall. An incorrect answer constitutes such a fall. A time limit should be given. Interest would be strengthened if the test were competitive: who can reach the top safely?

The regular testing of the class at the end of the term will bring to light any weaknesses in the work. Where some phase of the work has not "gone home" it should be repeated, but not in the same manner as at first presented. It should be approached from a different angle or angles, and with the hope that success will take the place of the first failure.

A good way of discovering whether children appreciate the difference in the meaning of the four processes is to give a test on the following lines. The test consists of four questions, in each of which the same numbers are used.

1. In a box are 35 pencils. I give 7 of them away. How many are left in the box?

2. In a box are 35 pencils. I share them among seven children. How many pencils has each child?

3. In a box are 35 pencils. I place 7 pencils with them. How many are now in the box?

4. In a box are 35 pencils. In another box are 7 times as many. How many are in the second box?

When children leave the Primary School they should possess definite notions of certain arithmetical fundamentals. They should know (*a*) the place value of a figure in a number, (*b*) the worth and use of zero, (*c*) how to discover an approximate answer to test their worked-out answer, (*d*) how to use the sign = correctly, (*e*) how the

s. d. 1 11 6 $2\frac{1}{2}$ 2 $4\frac{3}{4}$
16 × 4
$\frac{1}{4}$ lb. = oz.
d. $9\frac{1}{2}$ $-2\frac{3}{4}$
42 + 18 + 25 =
3) 76
$2\frac{1}{2} + 1\frac{1}{4} + 3\frac{1}{2} =$
62 − 17
6 × 7 =
14 − 9 =

reverse operations of × and ÷ will save time in working, (*f*) how to use their wits in finding short cuts to answers, (*g*) the meaning of fractions, and (*h*) how to use a ruler correctly.

In her book, *The Case Against Arithmetic*, E. M. Renwick discusses fully these fundamentals and the difficulties in "getting them over." Some of the following tests result from a study of her most provocative book. The tests should be given to fourth-year pupils in their last term. If children can answer the questions satisfactorily, they are very certainly advanced sufficiently for entrance to the Secondary School.

A. *Place Values*

Answers only are to be written.

1. What is the value of the 7 in 371?
2. How many times greater in value is the first 6 than the second 6 in 6265?
3. What is the thousands figure in 142857?
4. How many times less in value is the second 4 than the first 4 in 41243?
5. What is the ten-thousands figure in 285714?
6. How many tens make a thousand?
7. What is the value of the 2 in 78562?
8. Subtract six thousand seven hundred and thirty from 46731. What is the answer?

B. *The Value of Zero*

Rewrite these statements leaving out any o's that do not matter.

1. 3,020.	6. 9·60.
2. 19*s*. 0*d*.	7. 307,006.
3. 500.	8. £125 0*s*. 0*d*.
4. £20 0*s*. 5*d*.	9. 0·020.
5. 10·5.	10. 2,700·3.

C. *Approximations*

Copy, but put a whole number for each ?

1. $2\frac{3}{4}d.$ is between ?*d*. and ?*d*. It is nearer ?*d*.
2. £1 3*s*. 9*d*. is between £? and £?. It is nearer £?.
3. 767 is between ? hundreds and ? hundreds. It is nearer ? hundreds.
4. $9\frac{3}{8}$ is between ? and ?. It is nearer?.
5. £4 11*s*. 9*d*. is between £? and £?. It is nearer £?.
6. 3002 is between ? thousands and ? thousands. It is nearer ? thousands.
7. 4 hrs. 13 mins. is between ? hrs. and ? hrs. It is nearer ? hrs.
8. 2 tons 10 cwt. 3 qr. is between ? tons and ? tons. It is nearer ? tons.
9. A crowd of 68,272 is roughly ?
10. 1·62 is between ? and ?. It is nearer ?

D. *The Use of the Sign* =

Read these statements. If you think the sign = is used correctly throughout a line, write YES. Otherwise write NO. Each line requires the answer YES or NO.

1. 9*d*. × 2 = 18*d*. = 1*s*. 6*d*.
2. 10 × 3 = 30 ÷ 2 = 15.
3. 21 + 15 = 36 × 3 = 108.
4. 12 + 6 = 18 ÷ 3 = 6.
5. 15*s*. × 20 = £15 − 10*s*. 6*d*. = £14 9*s*. 6*d*.
6. 5 + 4 + 3 = 9 + 3 = 12.
7. $1\frac{1}{4} + \frac{1}{2} + 1\frac{1}{4} = 2 + 1 = 3$.
8. 28 ÷ 4 = 4 ÷ 28 = 7.
9. $6\frac{5}{8} - 2\frac{1}{2} = \frac{5}{8} - \frac{4}{8} = \frac{1}{8} = 4\frac{1}{8}$.
10. $\frac{1}{5}$ of 25 = $\frac{1}{2}$ of 10 = 5.

E. *Recognition that* $\times$ *and* $\div$ *are Reverse Operations*

Write the answers from mental working only. Do no paper working.

1. Divide 2×13 by 2.
2. Divide $2 \times 7 \times 5$ by 10.
3. Divide $4 \times 2 \times 6 \times 3$ by 12.
4. Divide $3 \times 2 \times 3 \times 11$ by 9.
5. Divide $2 \times 3 \times 4 \times 5$ by 2×5.
6. Divide $11 \times 3 \times 5 \times 2$ by 11.
7. Divide $2 \times 11 \times 2 \times 5$ by 20.
8. Divide $7 \times 5 \times 3 \times 4$ by 14.
9. Divide $6 \times 3 \times 2 \times 7$ by 42.
10. Divide $5 \times 8 \times 6 \times 3$ by 24.

F. *Working Mentally*

Work these sums mentally and write the answers.

1. 100×20.
2. $800 \div 40$.
3. $136 \div 136$.
4. $7{,}000 \times 100$.
5. $900 \div 30$.
6. 650×20.
7. $20{,}500 \div 500$.
8. $59 \times 14 - 59 \times 13$.
9. $60 \times 2{,}000$.
10. $1{,}000 \times 1{,}000$.

G. *Fraction Values*

Write the answers to the questions.

1. Which is greater $\frac{1}{5}$ or $\frac{1}{6}$?
2. What is the answer to $\frac{1}{2}$ of $\frac{1}{4}$?
3. Is the answer to $\dfrac{6}{\frac{1}{3}}$ greater or less than 6?
4. How many times greater is $\frac{7}{8}$ than $\frac{1}{8}$?
5. What must you add to $\frac{9}{11}$ to make 1?
6. What is left when you take $\frac{1}{8}$ from $\frac{1}{4}$?
7. Which is the greater, $\frac{1}{3}$ or $\frac{1}{2}$ of $\frac{1}{3}$?
8. How many $\frac{1}{4}$ are there in 3?

H. *The Use of the Ruler*

Lines (Fig. 19) are placed on the blackboard. It is explained to the class that the long portions of the lines are inches, and the smaller portions definite parts of inches. Children are required, without measuring, to state the length of the lines and the perimeter of the figure.

Ways and means of testing arithmetical progress in the individual school have been suggested, but there is another aspect of examination which has not yet been considered. A teacher may know, from a terminal test, if the work of his scholars is satisfactory or not. But there may come to his mind the very reasonable thought, "Those children of my class have done quite well. I wonder how they compare with the children in other schools?" To obtain the information required by that teacher, the same examination would have to be set to his class and large numbers of other classes. In fact, there would have to be devised a standard form of examination.

In one particular that is already being done. There is in a large number of counties the qualifying examination for entrance into the Secondary Grammar School. But at the present these county examinations cannot be classed as "standard." They vary so tremendously from county to county, and they vary to a large degree from year to year in the same county.

The production of a "standard" examination is no easy task. It might be thought to be simple; the sums of such a test will be either right or wrong. That is so, but many teachers are not satisfied (and rightly so) with marking the result; they prefer to give credit for the method by which the result was

obtained. A sum, worked methodically but having a small error, is often awarded more marks than one with a correct answer worked by a clumsy method.

There is also difficulty in setting sums. A slight difference in figures makes a vast difference in difficulty. For example:

1,352	1,312	1,312	1,302
−638	−178	−118	−178
(*a*)	(*b*)	(*c*)	(*d*)

look very similar, but they contain elements which constitute different degrees of trouble. In (*a*) two figures in the subtrahend are greater than the figures above them, but they are not adjacent. In (*b*) they are. In (*c*) the tens figures—both ones—are a constant source of error. In (*d*) is that ever-troublesome zero. Again, to a child nervously intent on passing the examination, the item of a sum stated as "How long are 24 pieces each 2 yd. 2 ft. 3 in. long?" is a greater test than if it were stated "How long are 24 pieces each $2\frac{3}{4}$ yd. long?"

To help teachers standard tests are available. Their compilers have had to overcome the difficulties just outlined. They have done so by setting large numbers of (*a*) mechanical sums, (*b*) mental sums, and (*c*) problems. These test in the fundamental requirements of the Primary School: a knowledge of the four processes, of the measures of money, weight, length, capacity, and time, of vulgar and decimal fractions.

The sums chosen are simple, but by their large numbers every type of difficulty in process and method is included. A time limit is set which is too short for all the sums to be attempted. Thus the most proficient scholars are picked out. The sums are tests of speed; therefore, although method is not specifically tested, the child who uses the correct manner of working will get most sums done.

In the few pages of this chapter detailed descriptions of available tests cannot possibly be given. One may be found somewhat fully explained and with a useful number of details in Dr. W. Boyd's *Measuring Devices* (Harrap).

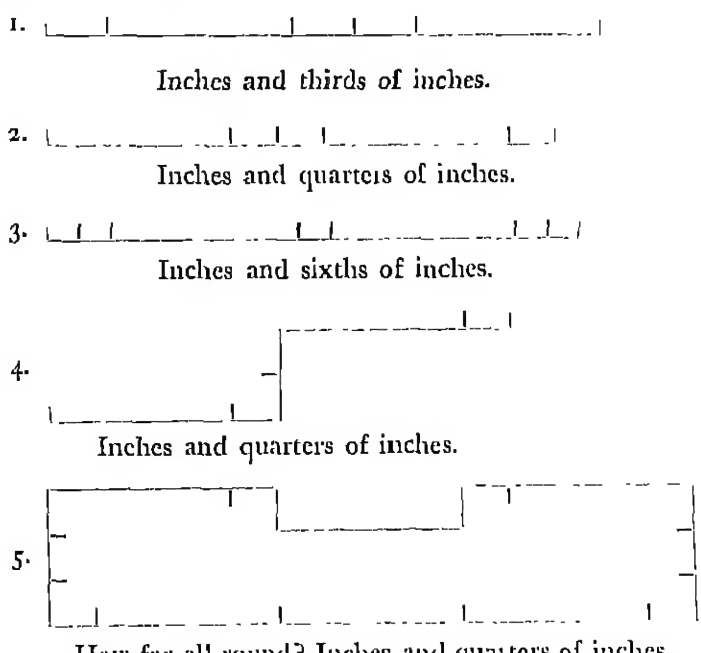


Fig 19.

American arithmeticians have made a specialized study of arithmetical testing, and have produced tests for various purposes. Descriptions of the Courtis Test B, the Woody Arithmetic Scales, the Boston Tests, the Cleveland Survey Tests, and the Kansas Diagnostic Tests may be found in *How to Measure*, by Dr. G. M. Wilson and Dr. Kremer J. Hoke (Macmillan).

The value of these tests is that they have been in use for quite a number of years, and standards of attainment from them have been made.

CHAPTER SEVENTEEN

CORRELATION WITH OTHER SUBJECTS

CHILDREN learn first by the use of their senses. From seeing and touching objects, and hearing sounds, ideas are moulded in their minds. For abstract thinking, the ideas must not be fleeting but must be strong, and firm links of association must be formed between them. These links of association can be forged by the presentation of facts from many points of view, and one way in which this varied presentation can be made is by correlation. Arithmetic has features common with many of the school subjects, and, just as the parts of arithmetic should be treated as a related whole, so should be treated these common features. Correlation should take place at all opportunities.

Let us consider points of relationship between our subject and some others.

Music

The practical use of fractions can be demonstrated in music lessons. In the third and fourth years, in the drawing of staves for manuscript writing, the five parallel lines should be $\frac{1}{8}$, $\frac{1}{10}$, or $\frac{1}{12}$ of an inch apart. Again, time signatures *used in music are fractions. The* old-time half-short, the semibreve, is now the unit of time measurement. From that unit the lengths of the other main notes are: the minim $\frac{1}{2}$, the crochet $\frac{1}{4}$, and the quaver $\frac{1}{8}$. Time signatures, showing the *constituent value* of each bar, are written as in Fig. 20.

Games and Sports

The measuring and marking of the playground for various activities such as net-ball, skittle ball, hop-jumping, call for the use of long measure. It is also in use in long and high jumping. Time measure plays its part in the *timing on the sports field of flat* races and hurdling. This putting into practice of a knowledge of arithmetic should be brought to the notice of children, especially those in their fourth year. In this year children could draw to scale the pitches used for the games of football, hockey, net-ball, rounders, and tennis. They could also measure out and draw charts showing annual sports records and house contests (Figs. 21 and 22).

Art

The normal mind delights in symmetry and design, and they are as *pleasing to the child as to the adult.* Opportunity should often be given the

$\frac{2}{2}$ $\frac{2}{4}$ $\frac{3}{4}$ $\frac{4}{4}$ $\frac{3}{8}$ $\frac{6}{8}$

2 MINIMS. 2, 3, OR 4 CROTCHETS. 3 OR 6 QUAVERS

Fig 20.

YEAR.	HOLDER.	EVENT.	TIME OR DISTANCE.

Fig. 21.

FOOTBALL LEAGUE. HOUSE—OXFORD.			
Versus.	*Goals for.*	*Goals against.*	*Points.*

Fig 22

child to invent and colour designs. He can draw them using rectangular and triangular areas. The designs used by different peoples at different periods for vase or pot or architectural decoration provide a wide scope for the correlation of arithmetic, art, and history. For example, a Greek Key pattern requires careful measurements, offers exercise in colour washing and the choice of blending colours, and recalls the grandeur of the Greek civilization (Fig. 23). See also History Charts for patterns.

To get accustomed to the use of the compass, and to prepare for the mathe-

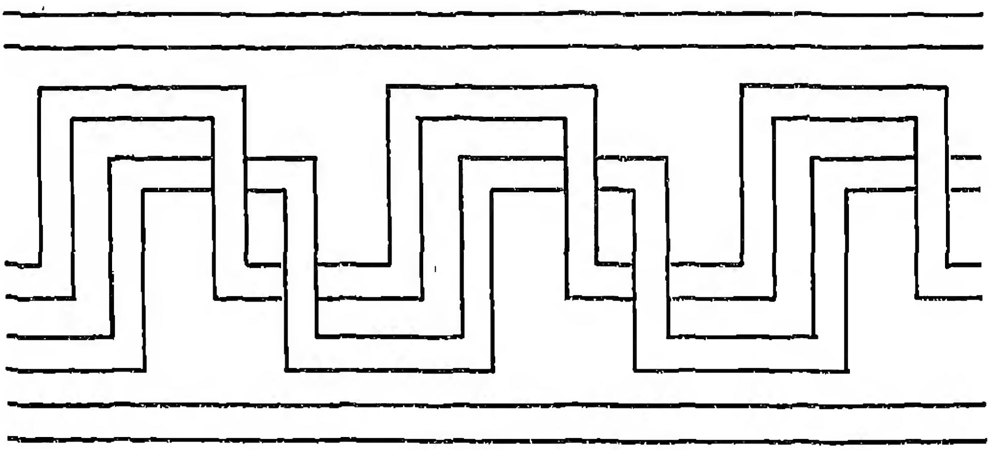
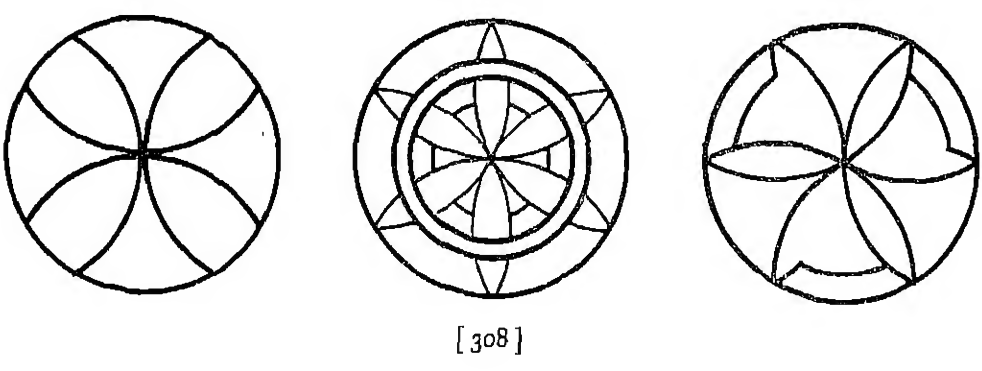


Fig. 23 AND (BELOW) Fig 24.



matics of the circle, children, even in the second year, should be encouraged to make and to colour circular designs (Fig. 24)

Poster work, announcing school concerts, sports, house events, could be executed by the children in their fourth year. Posters, to be effective, need thoughtful planning and perfect balance, and thus they require the careful use of the ruler.

Children find pleasure in producing their own anthologies of poetry and prose. The beauty of their exercise book could be enhanced by having for each entry a symmetrical heading and a decorated initial letter. Here, again, measuring and mathematical accuracy will warrant successful work.

Nature Study

Although the making of graphs does not normally enter into the work of the Primary School, some elementary knowledge of it would be useful in the correlation of arithmetic and nature study. It was suggested in connection with the daily five minutes' mental work that a child would be more interested if he should keep a record of his attainments. This could quite well be in the form of a simple graph, the vertical scale showing the number of correct sums and the horizontal the date. The child, in his fourth year, would readily realize the necessity for having a fixed scale both horizontally and vertically, and having learned that fact, no other difficulty would present itself. Once having used this method of making a "picture result," he could employ it to show daily readings of the 9 a.m. temperature of the classroom.

The measuring and setting up of charts for nature-study use could also be undertaken (Fig. 25).

Another chart could show the date of the breaking into leaf of different trees, of the first butterfly and the first returning migrant bird seen, of the first blooming of a wild flower, of unusual frosts or falls of snow, or other out-of-season weather conditions (Fig. 26).

WILD FLOWERS OF OUR DISTRICT.			
Date.	*Name of flower.*	*Where found.*	*Found by.*

Fig. 25.

OUR NATURE DIARY. *April.*				
1	2	3	4	5
6	7	8	9	10

Fig 26

Geography

One of the facts important in the geography lesson, namely, that of direction, can well be included in a ruler-work lesson in arithmetic. In the first year the four cardinal points of the compass will be explained as a part of the geography course (see Chapter II, Vol. III, GEOGRAPHY). It will then be possible to set sums such as the following: "Place a dot A on the top line of your book, and from it draw a line 3 inches to the east to a point B. From B draw a line of 4 inches to the south to a point C. Join the points A and C. How long is the line joining A to C?"

The interesting points NE., NW., SE., and SW., can then be explained and drawn, and similar sums to the above set to put them into practice.

In the fourth year the construction of the protractor should be discussed. Using it, angles and triangles should be drawn. This knowledge of angles will prove of value when, in geography, latitude and longitude, the angle of declination, and the finding of position by the sextant, are under consideration.

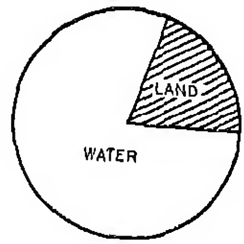


Fig. 27.

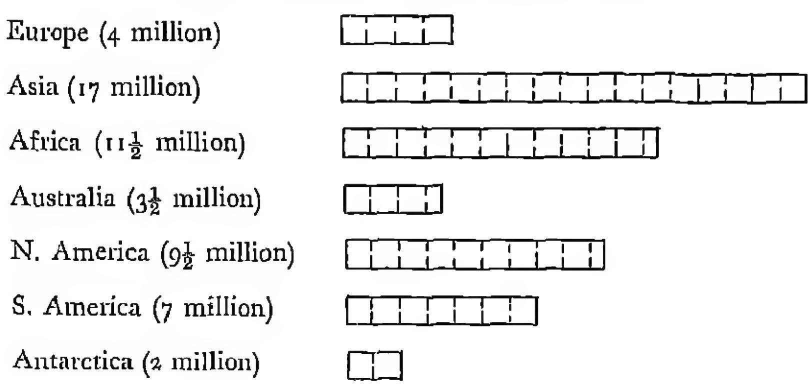
The protractor can also be used in making such visual aids as the above. It shows the comparative area between the land and the water forming the surface of the earth. The circle has to be divided in the proportion of 4 to 1, therefore the angle subtending the "land arc" will be 72° (Fig. 27).

Transport by bus and rail can be studied in time-tables. From them and an atlas can be ascertained distances, and the time taken to cover the distances can be calculated. *The intimate* reading of maps is an invaluable exercise.

As in nature study, graphs will find a useful place in geography. Simple ones of daily rainfall (shown not by a line joining dots, but by columns corresponding with depth of rain

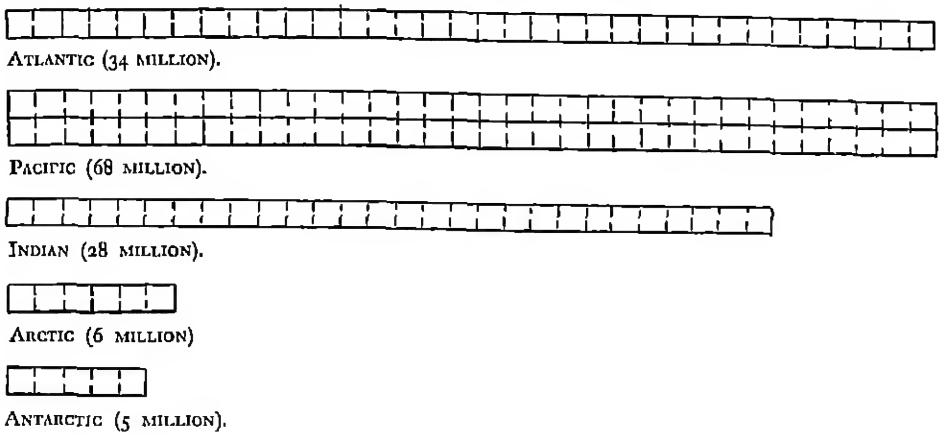
THE AREA OF THE CONTINENTS

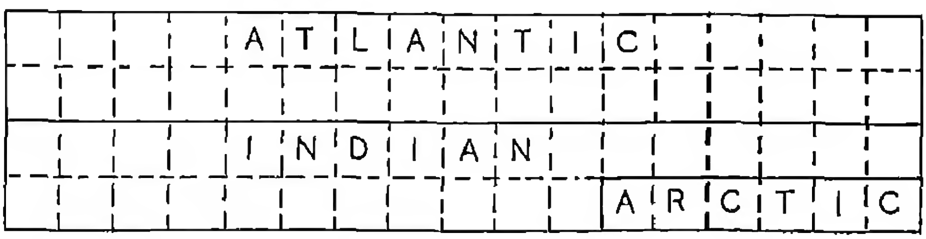
Scale 1 square = 1 million square miles.



THE AREA OF THE OCEANS

Scale 1 square = 1 million square miles.





fallen) and of the readings of the maximum and minimum thermometer should be made. A knowledge of graph-making will help, too, in the construction of contour sections, where the vertical scale shows heights and the horizontal scale shows distances.

Graph paper can usefully be used in another way to connect geography and arithmetic. Diagrammatic representations are valuable to the geographer. Examples are given of many diagrams which could be drawn on $\frac{1}{4}$-in. or $\frac{1}{2}$-in. squared paper.

Another diagram might show that the Pacific Ocean is equal in area to all the others, excluding the Antarctic. The whole oblong represents the Pacific Ocean.

Understanding of the movements of the earth and the facts of the changes of season can be aided by the use of the shadow-stick. The stick, some 8 or 9 inches long, is placed in a board, on which has been stuck paper marked with an evenly graduated scale. The length of the shadow cast by the stick is marked on the paper daily several times around noon. If this is done repeatedly for a year, first, exact north and south can be defined with certainty, and secondly, a graph of the varying lengths of the shadow can be drawn. It will then be seen that the shadow is longest in winter, and gradually decreases to the middle of summer It can be inferred that in summer the sun is higher in the sky,

and hotter weather is the result. If shadows are marked also in the morning and afternoon, it will be ascertained that the sun does not rise and set in the same place east and west at all times of the year.

On the occasion of an eclipse it is most interesting to register the temperature every two or three minutes. The graph which can be constructed from the readings gives excellent evidence of the effect on the earth of the withdrawal of the sun's direct rays.

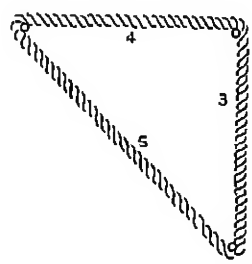
When working on areas children will probably use squared paper. The exercise of counting the squares to find the area of rectangular figures can be extended to correlation with geography in the finding of the area of an irregular shape, such as that of a city, a county, or a country.

There has been a connection between arithmetic and land surveying for several centuries. In quite early Egyptian times rentals for land on the banks of the Nile were not permanent but were assessed frequently. This was due to the effect on the land of the flooding of the river. After an inundation a new measurement of a plot of land was made and a rental fixed accordingly. To prepare for outdoor work on surveying, children in the arithmetic lesson should become acquainted with the manner in which measurements are recorded in the chain book. Specimen recordings, such as

	Chains.	
	A	
	17	
To C 5	13	
	8	To D 7
To E 5	4	
	B	

should be given them, from which to make readings, to make plans, and to find areas (see Chapter XIII).

Reference could be made here to the method used by the Egyptians for obtaining right angles. "Rope-stretchers" used an endless rope of length 12 units, knotted in 3, 4, and 5 units. The rope was stretched around three pegs, so that it formed a triangle of sides 3:4:5. The angle between the sides of 3 and 4 units was, of course, the right angle. "Rope-stretching" was a well-paid occupation, and the high rate of pay was maintained because the "stretchers" kept their method strictly secret.



The comprehension of maps is not simple. To help in the understanding of them, so essential to the geographer, plans should be made in the arithmetic periods. The ruler work of Years One and Two should conclude with the drawing to scale of such flat surfaces as the top of the classroom table, of the teacher's desk, of the pupil's desk. This scale drawing should continue in the third year with a plan of the school hall, of a cupboard door with its panels, and of a scholar's route to school (the scale being that of so many paces). The fourth-year scholars can then tackle the drawing of the school site and of some personal possession such as the front of a dog kennel, and finally can be set the reading of distances on a map

of an imaginary island, and the drawing of an island from measurements and directions given. With the child's possession of this background, the fact of a map being a plan should present no further difficulty.

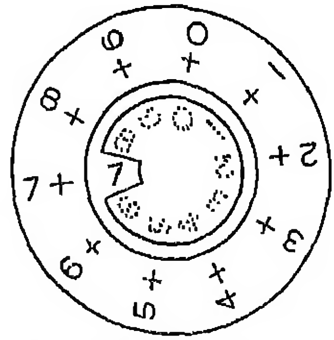
Handwork

There is a vast scope for correlation between handwork and arithmetic. Already there have been suggested in various chapters the construction of apparatus in handwork lessons for use in number work. They are catalogued here so that the full course is at once ready to hand.

Much construction work can be done in the handwork periods with two objects in view, namely, the training of the hand and the aiding of arithmetic. There should not be haphazard choice of objects to be made, but a course should be planned after due consideration has been given.

For *arithmetical processes*, "coins," weights, and measures can be cut out of gummed paper to give children ideas of the comparative value of the units used. Clocks can be made to help in the understanding of time. For quick working and revision in addition, subtraction, multiplication, and division, apparatus such as that illustrated should be constructed. This apparatus is made of three layers of cardboard working around a central pivot. For class use a large model should be made, and for individual use a small one.

Practice in addition and subtraction can be gained by the use of *games.*



THE INSIDE FIGURES ARE DOTTED TO SHOW THEY ARE ON THE SECOND CARDBOARD CIRCLE.

Shapes for use in these games can often be made in handwork lessons.

For *ruler work* each child should draw on and cut out of fairly stiff paper a six-inch ruler. On it should be marked inches, halves, and quarters. A second one should be made showing eighths, sixths, and twelfths, and a third one divided into tenths. For measurement exercises, gummed paper should be cut into squares, triangles, oblongs, and circles. The shapes can then be used to produce varied coloured patterns.

Areas, and *decimal and vulgar fractions,* can be taught by the drawing of shapes on squared paper. The construction of models from these shapes should form a part of the handwork course.

The idea of *volume* should be introduced by the moulding of Plasticine cubes and cuboids, and the construction of cardboard models.

It will be seen that much excellent practical value can be obtained by a close knitting of the subjects of hand work and arithmetic.

CHAPTER EIGHTEEN

GAMES AND PUZZLES

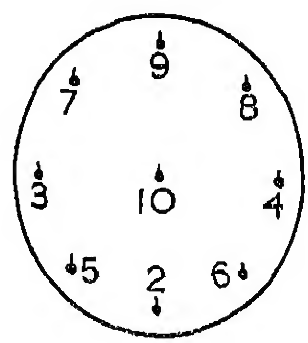
STRESS, in many parts of this book, has been placed on the necessity for the maintenance of interest in arithmetic. It has been said that without that interest there can be no progress, which is the object of the thought we put into our work. We are dealing with the child mind; we must force ourselves into the interests of that mind. Childhood is the playtime of life. Therefore, if we can enter with the child into the atmosphere of play, we shall obtain from him co-operation of effort. He will be helped to feel that his interests and ours are coincident. Arithmetic to the child is a form of work. Why should it not be a pleasurable form? Why should it not have its lighter moments? Why, through play, should not some part of the arithmetic course be done?

Many children have games which require a knowledge of number. Why, especially in the earlier years, should there not be a games arithmetic lesson to take the place of the "mental" period?

Numbers are employed in race games, ludo, marble alleys, bagatelle, skipping, long and high jumping, and in many another pastime. Really practical and useful arithmetic can be done by the utilization of such games and activities. If the actual games are not available, imaginative sums in connection with them will give a class times of pleasant working.

First Year

The Ring Board provides for skill and amusement. If one is in the possession of a child, let the class use it one morning and work sums finding the totals of the scores made. If one is not obtainable, draw one on the board, and set questions on a fictitious game played by the scholars.



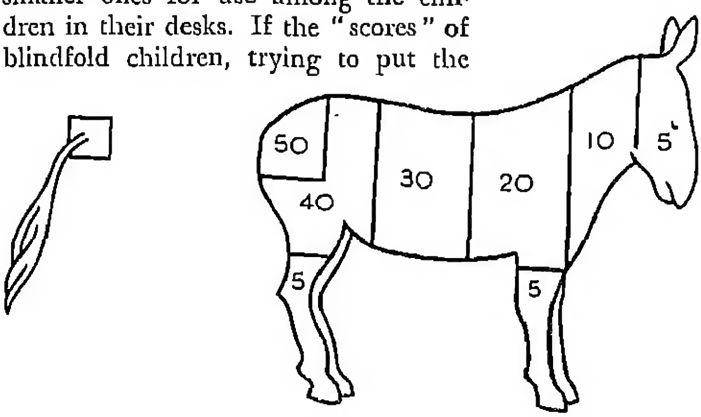
Such questions could be: "4 children played. They each had 4 rings.

1. William scored 6, 10, and 3. How many altogether?
2. Mary scored 9, 4, and 7. How many altogether?
3. Sam scored 3, 2, and 9. How many altogether?
4. Jane scored 8, 10, and 4. How many altogether?
5. Who made the highest score?
6. Who scored the least?
7. Add together Mary's and Jane's scores.
8. Add together William's and Sam's scores.

9. By how many did the girls beat the boys?"

Similar sums could be set in connection with a marble alley, a dart-board, a race game, etc. The personnel playing could be varied. Teams of children might be pitted against teams of teachers, or of parents, or of scholars from another school.

Great fun and useful work can follow the cutting out in handwork lesson of cardboard pigs or donkeys. They can be used to play the game of "The Tailless Animal." A large cut-out could be made for blackboard and class use, and smaller ones for use among the children in their desks. If the "scores" of blindfold children, trying to put the



drawing-pinned tail in the correct place are recorded, good practice may be done in both addition and subtraction processes.

SECOND YEAR

A variation of the above, using some other animal, could correlate handwork with the revision of first-year arithmetic.

The games played in the first year could again be used, but with the employment of larger numbers for scoring purposes.

The scores made by boys in a cricket match form an interesting variation.

THIRD YEAR

It is suggested that the somewhat complicated scoring of the domino game of "5's and 3's" be introduced here. It forms an excellent means of testing and revising tables, and of *simple multiplication and division.*

FOURTH YEAR

A fascinating game is "Nine Men's Morris." The board and counters required for it may quite easily be made in a handwork period. The counters number 24, the size of a sixpence, and they are 12 each of two colours. The game, similar but more difficult than "Noughts and Crosses," *although* not strictly numerical, provides scope for what we in arithmetic try to teach, namely, logical thinking. Each player is given 12 counters of the same colour. One commences, and he can place one of his counters on any one of the 24 points of intersection of lines. The second player then places one of his counters on any one of the vacant 23 points. The object of the game is to place three counters in a line up, down, or across. On obtaining such a line a player removes any one of his opponent's *counters from the board* Alternately the players cover a point with a counter. When they have placed all their 12 counters on the board, they can move any counter to any vacant point adjacent to the point covered by the counter. When a player is reduced to three counters, he may

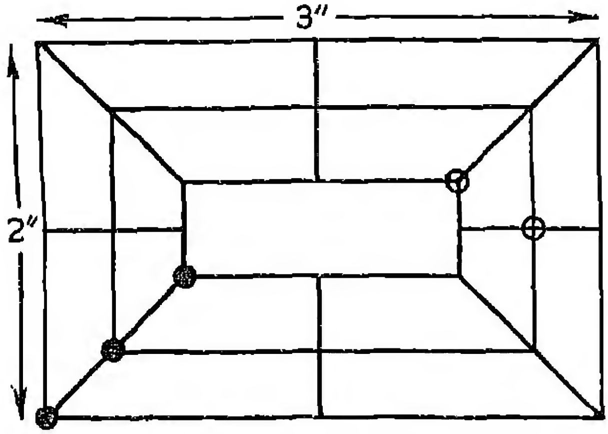


FIG. 28 (SCALE 1 IN. TO 2 IN.)

"hop" any counter to any vacant point. The game is won and lost when one player has but two counters on the board (Fig. 28).

A class competition to find the champion "Nine Men's Morris" player gives rise to much enjoyment and enthusiasm.

In the chapter on Instrument Work information was given on the construction of drawn-to-scale puzzles. It is not necessary here to repeat the suggestions made in that chapter. To them may be added the use of the compass in the production of puzzles. A circle is drawn

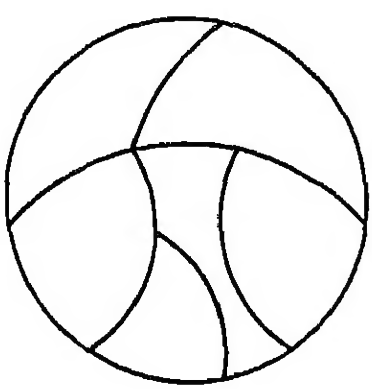


Fig. 29.

with a radius, say, of 2 in. Then arcs are drawn within it of radii $2\frac{1}{4}$ in. and $1\frac{3}{4}$ in. The parts are cut out, the puzzle being to reassemble them. If the paper used is perfectly blank on both sides, the remaking of the circle presents no little difficulty (Fig. 29).

Children find delight in doing all sorts of puzzles. They can and should be utilized in the teaching of arithmetic.

The Magic Square is always a source of interest. I have found it command the earnest atten-

8	4	3
6	2	7
1	9	5

tion of children of the second year. A specimen may be given them, using the numbers 1 to 9. It will be seen by the class that whether additions be made vertically or horizontally the total in each and every case is 15. They should be invited to make similar squares using numbers from 3 to 11 to make the lines total to 21, from 4 to 12 for a total of 24, and so on.

Sums with a "catch" in them evoke pleasure. Here are some suggestions.

1. A candle burns for 6 hours. If 4 candles are lit together, for how many hours will they burn?

2. Divide 111111 by 11. What is the quotient?

3. If a boy and a girl have 10 toes each, how many toes are there in 8 shoes?

4. It takes $3\frac{1}{2}$ minutes to boil an egg, how long will it take to boil the 5 eggs which are put into a pan together?

5. How much for a shillingsworth of oranges at 2 for 9*d.*?

6. If a silk stocking lasts 4 months, how long will a pair of silk stockings last?

7. A little boy's head was 16 in. above the seat of a stool 1 ft. high. If he moved from the stool and sat on a chair 2 ft. high, how far above the seat of the chair would his head be?

8. A clock on a wall says it is a quarter to ten. Opposite it is a looking-glass. What time will it appear to be in the looking-glass?

9. If plants in a garden are placed 1 ft. apart, how far along a row will the first plant be from the tenth?

10. If 6*d.* is shared between two boys so that one gets 1*d.* more than the other, how much does each get?

11. In three envelopes is placed a total of £100. They are placed in a safe one above the other. The middle one contains £1 more than the top one, and £1 less than the bottom one. How much is in each envelope?

12. A collection was taken at a school concert. The amounts collected were written down, but the writer was careless and mixed them up. Can you sort them out?

	£	*s.*	*d.*
Half-crowns . .	6	5	11
Florins	4	13	0
Shillings	21	8	6½
Sixpences	1	3	7½
Pence	3	12	6
Halfpence . . .	2	15	6
Total	2	18	0

Another form of puzzle is the "Arithmorem." In this puzzle the letters of a word are mixed up, and for some of them Hindu-Arabic numerals are substituted. These numbers have to be changed to their Roman equivalents, and the disguised word can then be found. Examples are:

No 51 = an animal (Answer Lion. 51 = LI).

Dde 7 = to separate into parts. (Divide. 7 = VII).

Eeorp 40 = to search thoroughly (Explore. 40 = XL).

Ussse 200 = accomplishment (Success. 200 = CC)

Ake 250 = sound made by a bird (Cackle. 250 = CCL).

Esere 111 = a lesson or task (Exercise. 111 = CXI).

Eeie 104 = to accept (Receive. 104 = CIV).

Gn 57 = active (Living. 57 = LVII).

Oe 1111 = country of America. (Mexico. 1111 = MCXI).

Bun 551 = a capital of a country (Dublin. 551 = DLI).

A further kind of puzzle in which numbers can be used is the Code. The writing of something for something else, and the attempt to decipher that something else, never fails to claim interest. Quite a good code is this:

A	B	C	D	E	F	G	H	I	L	M	N	O.
1	2	3	4	5	6	7	8	9	¼	½	¾	⅛

The other letters of the alphabet are represented by 0.

The work might be presented in this manner. Put the code on the board and tell children to decipher such a message as this:

31¼¼ 8505 ⅛0 054¾50410.

Another way of presenting the puzzle is to withhold the code, but to give a message and then to show that in a code. A second message in the

same code is given, and that has to be deciphered. The children could be told, "Here is a message, and it is in a code.

THE RACE HAS BEEN RUN
K85 H135 81J 255D HLD

Here is another message in the same code. Can you find out what the message is?"

ELH K51C 31C5 9D J53ED4

This is a subtraction sum. Scholars are told that the letters stand for figures. Can they turn them into figures so that the sum is correct?

$$\begin{array}{r} B\ A\ D\ D \\ -\quad D\ B\ D \\ \hline D\ C\ A \\ \hline \end{array}$$

The logical reasoning is that since in the units column D − D must equal 0, A must be 0. The sum can therefore be started

$$\begin{array}{r} .\ 0\ .\ . \\ .\ .\ . \\ \hline .\ .\ 0 \\ \hline \end{array}$$

Since there is no thousands figure in the answer, B must be 1. The sum may be continued

$$\begin{array}{r} 10\ .\ . \\ .\ 1\ . \\ \hline .\ .\ 0 \\ \hline \end{array}$$

D must be greater than 2, since on subtracting 1 from it (in the tens) neither A (0) nor B (1) is left. Therefore in the tens there will be no need to add to the minuend. And in the hundreds there will be similarly no need to add to the subtrahend. So as 10 − D = D, D must equal 5, and the sum will become

$$\begin{array}{r} 1\ 0\ 5\ 5 \\ -\quad 5\ 1\ 5 \\ \hline 5\ 4\ 0 \\ \hline \end{array}$$

with A = 0, B = 1, C = 4, and D = 5.

That is not at all easy. Simpler puzzles using almost the same idea are the following. The instructions to the class are: "In these sums some figures are left out and are shown by small crosses. Find what the figures should be, and put them in."

$$\begin{array}{r} 2718 \\ \times 59 \\ \hline x3x6 \\ 794 \\ \hline 814x \\ \hline \end{array} \qquad \begin{array}{r} 4x1x \\ -x8x1 \\ \hline 2322 \\ \hline \end{array} \qquad \begin{array}{r} 3x7 \\ 6x \\ \hline 2082 \\ 1x41 \\ \hline 2x8x1 \\ \hline \end{array}$$

"In this sum the same figure is left out each time. Can you find out what it is?"

$$\begin{array}{r} 5\ x\ 8\ 4 \\ -x\ 9\ 1\ x \\ \hline x\ 3\ 7\ x \\ \hline \end{array}$$

In all these types of puzzles children will wish to show their inventiveness. Let them do so. Let them set problems for the rest of the class. He will be a proud scholar who mystifies completely his fellow-pupils.

CHAPTER NINETEEN

A NUMBER OF THINGS ABOUT NUMBER

THIS chapter is a miscellany of facts concerning numbers. It is intended to be helpful both to the teacher and to his class. Nothing is more annoying than to know a thing, to have it "on the tip of the tongue," but still to be unable to state it. The following pages are ready to relieve such an untoward situation. They contain facts and figures and suggestions for the use of "tricks of the trade" when employing facts and figures.

At the risk of being criticized for repetition, some facts here recorded have been dealt with in foregoing pages. Their inclusion is to save the teacher from wasting his time and making what often is an unfruitful search.

Natural Measures

Inch = length of nail joint of index finger or of thumb joint.
Palm = four fingers' breadth, or 3 in.
Hand = total width of hand, or 4 in.
Span = 9 in.
Foot = average length is 10 in.
Cubit = distance from elbow to tip of long finger, or 17 or 18 in.
Pace = 27 to 30 in.
Yard = distance from chin to tip of finger of outstretched arm.

The above are measurements of the average adult. Children would often find useful a record of their own individual "natural" measurements.

Weights and Measures

The weights and measures of Great Britain were standardized by the Act of 1878. It was necessary only to make standard units of the yard and the pound, for a gallon is the volume of 10 lb. of distilled water (under certain atmospheric conditions), an Apothecary's grain is the same as the Avoirdupois grain, and the Apothecary's ounce the same as the Troy ounce. Thus there is complete relationship among the various measures.

Length

The diameter of a sixpence is ¾ in.
The diameter of a halfpenny is 1 in.
A circle of 7 yards diameter has a circumference of a chain.
A cricket pitch (between the wickets) is a chain, or 22 yd.
An Association Football pitch (full size) is 120 yd. by 80 yd.
A Rugby Football pitch (full size) is 110 yd. by 75 yd.
A Lawn Tennis court is, for doubles, 78 ft. by 36 ft., and for singles, 78 ft. by 27 ft.
A furlong was the length a team of oxen could plough before taking a rest.
A pole is said to be a measure determined by the length of the goad used in driving the oxen team.
An English ell measured 45 in.

1 fathom is 6 ft., 100 fathoms 1 cable length, and 10 cable lengths 1 nautical mile.

The Geographical mile is the length of one minute of latitude. At the Equator it is 6,046 ft., and at the Poles 6,108 ft. The Nautical mile should be the same as the Geographical mile, but the Admiralty determines it as 6,080 ft.

Capacity

1 teacup holds $\frac{1}{4}$ pint. 1 breakfast-cup holds $\frac{1}{2}$ pint.

1 tumbler holds $\frac{1}{2}$ pint.

1 tablespoon holds $\frac{1}{2}$ fluid ounce ($\frac{1}{40}$ of a pint).

1 dessert spoon holds $\frac{1}{4}$ fluid ounce ($\frac{1}{80}$ of a pint).

1 teaspoon holds $\frac{1}{8}$ fluid ounce ($\frac{1}{160}$ of a pint).

Weight

3 pennies weigh 1 oz.

2 halfpennies and 1 farthing weigh $\frac{1}{2}$ oz.

1 gallon of water (distilled) weighs 10 lb.

1 cub. ft. of water weighs 62 32 lb.

1 brick weighs about 7 lb.

A Smithfield stone (for dead meat) is not 14 lb., but 8 lb.

A gallon of honey weighs 12 lb.

A quartern loaf normally weighs 4 lb.

Other Facts Concerning Weights and Measures

A bushel of apples averages 40 lb.

A barrel of butter is 4 firkins, or 224 lb.

A bushel of coal weighs 80 lb.

A bale of U.S.A. cotton weighs from 450 to 550 lb.

A peck of flour weighs 14 lb., a bag 140 lb.

A sack of potatoes weighs 112 lb.

A chest of tea weighs 84 lb.

100 lb. of wheat produce 70 lb. of flour.

100 lb. of flour produce 130 lb. of bread.

A truss of straw weighs 36 lb.

A truss of old hay weighs 56 lb.

A Welch fire-brick measures 9 in. by $4\frac{1}{2}$ in. by $2\frac{3}{4}$ in.

When wishing to compile sums it often occurs that the teacher is at a loss for sufficient data. The above may be of help, and so, too, may the following facts. It would be of much value to include Sports Records and Trade Statistics, but they vary so frequently that their insertion here would not give true, up-to-date facts. Much useful information can be found by the teacher in Whitaker's Almanack and in Board of Trade returns.

Railway Gauges

In Great Britain, U.S.A., Canada, and Western Europe the gauge is 4 ft. $8\frac{1}{2}$ in.; in the U.S.S.R., 5 ft. 0 in.; in Spain and Portugal, 5 ft. 6 in.; in New Zealand, South Africa, parts of Australia and Japan, 3 ft. 6 in.; and in Ireland, 5 ft. 3 in. The width of the roadway required for a single track of 4 ft. $8\frac{1}{2}$ in. gauge is 12 ft., for a double track 23 ft.

Bells and Watches on Board Ship

The ship's bell is rung every half-hour.

The ship's watches are

First—8 p.m. to midnight.
Middle—midnight to 4 a.m.
Morning—4 a.m. to 8 a.m.
Forenoon—8 a.m. to noon.
Afternoon—noon to 4 p.m.
First Dog—4 p.m. to 6 p.m.
Last or
Second Dog—6 p.m. to 8 p.m.

SPEED OF SHIPS

A knot is the measure of the speed of a ship. 1 knot is the equivalent of 1·1515 miles per hour.

CONCERNING PAPER

24 sheets = 1 quire. 20 quires = 1 ream.

Sizes of printing paper:
Imperial is 30 in. by 22 in.
Cartridge is 26 in. by 21 in.
Royal is 25 in. by 20 in.

Sizes of Writing-paper:
Imperial is 30 in. by 22 in.
Foolscap 17 in. by $13\frac{1}{2}$ in.
Pott is 15 in. by $12\frac{1}{2}$ in.

FACTS THAT CHILDREN should have at their finger-tips, and "Tricks of the Trade" in the use of those facts.

A. Eight $1\frac{1}{2}$*d.*'s make 1*s.*
Four 3*d.*'s make 1*s.*
Two 6*d.*'s make 1*s.*

To find the cost in shillings, divide x articles at $1\frac{1}{2}$*d.* by 8, x articles at 3*d.* by 4, and x articles at 6*d.* by 2.

Sixteen 1*s.* 3*d.*'s make £1.
Fifteen 1*s.* 4*d.*'s make £1.
Twelve 1*s.* 8*d.*'s make £1.

To find the cost in pounds divide x articles at 1*s.* 3*d.* by 16, x articles at 1*s.* 4*d.* by 15, and x articles at 1*s.* 8*d.* by 12.

Five times 4*s.* make £1.
Four times 5*s.* make £1.

To find the cost in pounds, divide x articles at 4*s.* by 5, and x articles at 5*s.* by 4.

B. To find the cost of 12 articles.
12 farthings = 3*d.* 12 pence = 1*s.*

Therefore change the cost of one article to pence and farthings, call the pence shillings and the farthings threepences. Thus: 12 articles at $3\frac{3}{4}$*d.* cost 3*s.* 9*d.*

12 articles at 1*s.* $3\frac{1}{2}$*d.* = 12 articles at $15\frac{1}{2}$*d.* *cost* 15*s.* 6*d.*

C. To find the cost of 240 articles.
240 pence = £1.

Therefore turn the cost of one article to pence and farthings, call the pence pounds and the farthings fractions of a pound.

240 articles at $11\frac{1}{4}$*d.* cost £$11\frac{1}{4}$ = £11 5*s.* 0*d.*

240 articles at 1*s.* $4\frac{3}{4}$*d.* = 240 articles at $16\frac{3}{4}$*d.* cost £16 15*s.* 0*d.*

D. Using the fact that 1,000 pence = £4 3*s.* 4*d.*

Cost of 1,250 articles at 1*d.*

= £4 3*s.* 4*d.* + (£4 3*s.* 4*d.* ÷ 4)
= £4 3*s.* 4*d.* + £1 0*s.* 10*d.*
= £5 4*s.* 2*d.*

E. Multiplying and dividing by 10 and powers of 10.

As ours is a decimal notation, multiplying and dividing by 10 and powers of 10 are simple matters.

To multiply by 10 add a 0, by 100 add two 0's, by 1,000 add three 0's, and so on. Thus:

$765 \times 10 = 7{,}650$; $765 \times 100 = 76{,}500$.

To divide by 10 cut off the units figure, by 100 cut off the tens and units figures, by 1,000 cut off the hundreds, tens and units figures, and so on. In each case call the numbers cut off remainders. Thus:

$765 \div 10 = 76$ *rem.* 5;
$765 \div 100 = 7$ *rem.* 65.

These facts can be utilized to simplify other multiplications and divisions.

$$20 = 10 \times 2.$$

$$\text{Therefore } 765 \times 20 = 765 \times 10 \times 2 = 7{,}650 \times 2 = 15{,}300$$

$$\text{And } 765 \div 20 = 765 \div (10 \times 2) = 76 \cdot 5 \div 2 = 38 \cdot 25.$$

Similarly, multiplication and division may be done by 30, 40, 50, etc., 300, 400, 500, etc., 3,000, 4,000, 5,000, etc.

Another use may be made of these multiplications by 10 and powers of 10.

$$99 = 100 - 1.$$

$$\text{Therefore } 765 \times 99 = 765 \times 100 - 765 \times 1 = 76{,}500 - 765 = 75{,}735.$$

$$202 = 200 + 2. \text{ Therefore}$$

$$765 \times 202 = 765 \times 200 + 765 \times 2 = 153{,}000 + 1{,}530 = 154{,}530.$$

F. Factors of 100 and 1,000.

$25 \times 4 = 100$. $125 \times 8 = 1{,}000$. $250 \times 4 = 1{,}000$.

To multiply by 25, multiply by 100 and divide by 4.

To divide by 25, divide by 100 and multiply by 4.

$$25 \times 4 = 100.$$

$$\text{Therefore } 765 \times 25 = 765 \times 100 \div 4 = 76{,}500 \div 4 = 19{,}125.$$

$$25 \times 4 = 100.$$

$$\text{Therefore } 765 \div 25 = 765 \div 100 \times 4 = 7 \cdot 65 \times 4 = 30 \cdot 6.$$

To multiply by 125 or 250, multiply by 1,000 and divide by 8 or 4 respectively.

To divide by 125 or 250, divide by 1,000 and multiply by 8 or 4 respectively.

$$125 = 1{,}000 \div 8.$$

$$\text{Therefore } 765 \times 125 = 765 \times 1{,}000 \div 8 = 765{,}000 \div 8 = 95{,}625.$$

$$250 = 1{,}000 \div 4$$

$$\text{Therefore } 765 \div 250 = 765 \div 1{,}000 \times 4 = \cdot 765 \times 4 = 3 \cdot 06.$$

G. Amounts near to even amounts.

19*s.* 11½*d.* is almost £1. Therefore

$$19s.\ 11\tfrac{1}{2}d. \times 82 = £82 - \tfrac{1}{2}d. \times 82 = £82 - \ 3s.\ 5d. = £81\ 16s.\ 7d.$$

10*s.* 0¾*d.* is roughly 10*s.* Therefore

$$10s.\ 0\tfrac{3}{4}d. \times 82 = 10s. \times 82 + \tfrac{3}{4}d. \times 82 = £41 + 5s.\ 1\tfrac{1}{2}d. = £41\ 5s.\ 1\tfrac{1}{2}d.$$

4*s.* 11¾*d.* is almost 5*s.* Therefore

$$4s.\ 11\tfrac{3}{4}d. \times 82 = 5s. \times 82 - \tfrac{1}{4}d. \times 82 = £20\ 10s. - 1s.\ 8\tfrac{1}{2}d. = £20\ 8s.\ 3\tfrac{1}{2}d.$$

H. Subtraction and Division before Multiplication.

As multiplication of numbers gives an increase in the answer, and as errors tend to be more when greater numbers are manipulated, it is usually sensible to lessen numbers by subtraction or division before multiplying. Of course, this suggestion cannot be followed in such a sum as $264 - 8 \times 13$.

Examples are:

$$£62\ 11s.\ 7\tfrac{1}{2}d. \times 57 - £62\ 11s.\ 7\tfrac{1}{2}d. \times 39 = £62\ 11s.\ 7\tfrac{1}{2}d. \times 18, \text{ and}$$

$$\frac{2{,}613 \times 321}{13} = 201 \times 321 = 64{,}200 + 321 = 64{,}521.$$

J. Useful Similarities.

12*d.* = 1*s.*

12 in. = 1 ft.

20*s.* = £1

20 cwt = 1 ton.

Eight $1\frac{1}{2}$*d.*'s = 1*s.*

Eight 2*s.* 6*d.*'s = £1.

$\frac{1}{10} = \cdot 1 = 10\%$ $\quad \frac{1}{4} = \cdot 25 = 25\%$

$\frac{2}{10} = \cdot 2 = 20\%$ $\quad \frac{1}{2} = \cdot 5 = 50\%$

$\frac{3}{4} = \cdot 75 = 75\%$

K. Parts of a Yard.

$\frac{1}{4}$ yd. = 9 in. $\frac{1}{2}$ yd. = 1 ft. 6 in.

$\frac{3}{4}$ yd. = 2 ft. 3 in.

L. Tests of Division.

2 will divide exactly into all even numbers.

3 will divide exactly into a number if the sum of the digits is exactly divisible by 3.

4 will divide exactly into a number if the last two digits are exactly divisible by 4.

5 will divide exactly into a number if the last two digits of the number are 25, 50, or 00.

9 will divide exactly into a number if the sum of the digits of the number exactly divides by 9.

11 will divide exactly into a number if the difference of the sums of the digits in the odd and even places is 0, 11, or a multiply of 11.

M. Checking Answers.

Addition may be checked by adding together the lines of the sum except one, and subtracting the answer from the answer of the sum. The difference should be the omitted line of the addition sum.

Subtraction may be checked by adding the answer to the subtrahend to make the minuend, or by subtracting the answer from the minuend to make the subtrahend.

Multiplication and division may be checked by doing the reverse operation. Care must be taken with remainders.

Fanciful Facts about Figures

1. If a number of two or three digits is thought of, and if the digits of the number are reversed and subtracted from the first number (or vice versa), it is always possible to name one figure of the answer. Suppose the first number thought of is 85, the reversal will be 58, and the difference 27. If 7 is stated as one figure of the answer, the other can with certainty be said to be 2. The sum of the digits is always 9.

If the number is of three digits, the middle digit of the answer is always 9, so, if the hundreds figure is stated, the units figure can be named, for again those two digits add up always to 9.

2. The following is somewhat similar to number 1. Write down any number. Write another number, using the same digits, but placing them in any order. Subtract, and the answer is always divisible by 9. Example:

$$\begin{array}{r} 42{,}589 \\ -\,29{,}458 \\ \hline 13{,}131 \\ \hline \end{array}$$

3. Although recurring decimals do not find a place in the Primary School, facts resultant upon them are interesting One would not give the following explanations to children of 10, but the sums without the explanations would fascinate them.

$\frac{1}{9} = \cdot\dot{1}$, which is $\cdot 1111+$

$\frac{2}{9} = \cdot\dot{2}$, which is $\cdot 2222+$, and so on.

Other fractions, connected with $\frac{1}{9}$,

also form recurring decimals. For example,

$$\tfrac{1}{27} = \cdot\dot{3}\dot{7}$$

$$3 \times \tfrac{1}{27} = \tfrac{1}{9} = \cdot 1111 +$$

$$\text{Therefore } 3 \times \cdot\dot{3}\dot{7} = \tfrac{1}{9} = \cdot 1111 +$$

$$\text{or } 3 \times 37 = 111\cdot$$

Following this (and this is what could be shown to children to entertain them and to prove that figures are interesting things):

$3 \times 37 = 111$	$1+1+1=3$
$6 \times 37 = 222$	$2+2+2=6$
$9 \times 37 = 333$	which gives the
$12 \times 37 = 444$	number by which
$15 \times 37 = 555$	37 is multiplied.
$18 \times 37 = 666$	
and so on.	

Again, $\frac{1}{81} = \cdot\dot{1}234567\dot{9}$

$$9 \times \tfrac{1}{81} = \tfrac{1}{9} = \cdot 1111 +$$

$$9 \times 12345679 = 111111111$$
$$18 \times 12345679 = 222222222$$
$$63 \times 12345679 = 777777777$$

Or multiplying the same number by 3 or a multiple of 3 (which is not also a multiple of 9),

$$3 \times 12345679 = 37037037$$
$$21 \times 12345679 = 259259259$$

4. There can be compiled with figures some strange tables. They could on occasion be used to ease the tension of a lesson. Their use should not be too frequent. Children might like to be given the tables as stated here and continue them for 9 lines each. They unfortunately entail very lengthy multiplications.

$$1 \times 1 = 1$$
$$11 \times 11 = 121$$
$$111 \times 111 = 12321$$
$$1111 \times 1111 = 1234321$$

$$2 \times 2 = 4$$
$$32 \times 32 = 1024$$
$$332 \times 332 = 110224$$
$$3332 \times 3332 = 11102224$$
$$33332 \times 33332 = 1111022224$$

$4 \times 4 = 16$	$9 \times 9 = 81$
$34 \times 34 = 1156$	$99 \times 99 = 9801$
$334 \times 334 = 111556$	$999 \times 999 = 998001$

$1 \times 8 + 1 = 9$	$1 \times 9 + 2 = 11$
$12 \times 8 + 2 = 98$	$12 \times 9 + 3 = 111$
$123 \times 8 + 3 = 987$	$123 \times 9 + 4 = 1111$
$1234 \times 8 + 4 = 9876$	$1234 \times 9 + 5 = 11111$

CHAPTER TWENTY

BIBLIOGRAPHY

OF all teachers, the teacher of arithmetic can get most easily into a groove. He has to deal with the same old numbers, unchanged and unchanging through centuries, unalterable in their eternal relationships. In contrast, many subjects of the curriculum are affected by new influences and new exponents. Music, for instance, is ever changing in response to the spirit of the age: it has its clashes amongst the adherents to melody and classical harmony, the inventors of new harmonies and discords, and those who prefer a preponderance of rhythm. The teacher of history cannot exclude from his considerations changed social conditions and new world-orders. Geography must deal with new groupings of nations, new national boundaries, and new international trade developments. The teacher of art finds a new technique being developed and has to consider whether the innovation shall be allowed or be employed to influence the work of the class. But arithmetic, like Classical Latin and Greek, is static.

1 and 1 make 2. No cubist art, no world war, no swing music, no change of national ideology can alter that fact. It is constant, and with it, and similar unalterable facts, the teacher of arithmetic has year in and year out to deal.

But the methods of arithmetic are not static. During the last fifty years they have undergone an evolution, due to the work of many who have given years of thought to the subject. The results of the labour of these thinkers are available in many excellently written books. Some of them are here listed, and it is my advice to the teacher who would not carve for himself a deepening groove to read all that he can obtain.

They will keep him alive to his subject, and his avidity will be reflected in the work of his class.

A. Pupils' Class Text-book

The pages of this book have been written by one who, for many years, has been a member of the teaching profession. During those years he has had much experience in the teaching of arithmetic. That experience he put, a few years ago, into a set of class books for the Primary School. This present book is based largely on the scheme worked out in those class books.

JUNIOR WORKADAY ARITHMETIC, by H. Bates (Cassell, 1941). Four books for first-, second-, third-, and fourth-year Primary School work.

B. Board of Education Publications
(Now Ministry of Education)

HANDBOOK OF SUGGESTIONS TO TEACHERS. 1937.

SUGGESTIONS FOR THE TEACHING OF ARITHMETIC. Circular 807.

SPECIAL REPORTS on Educational Subjects: (1) The Teaching of Arithmetic in London Elementary Schools;

(2) Teaching of Arithmetic in English Elementary Schools.

REPORT of Consultative Committee on the Primary School. 1931.

C. History of Mathematics

A HISTORY OF ELEMENTARY MATHEMATICS. Cajori (Macmillan).

A SHORT ACCOUNT OF THE HISTORY OF MATHEMATICS. Rouse-Ball (Macmillan).

A SHORT HISTORY OF MATHEMATICS. Sanford (Houghton, Mifflin Co., Boston, U.S.A.).

TEACHING OF ARITHMETIC THROUGH 400 YEARS. Yeldham (Harrap).

HISTORY OF ARITHMETIC. Karpinski (Rand, McNally. Chicago).

THE STORY OF ARITHMETIC. Cunnington (Allen & Unwin).

SHORT HISTORY OF MATHEMATICS. Sanford (Harrap).

INTRODUCTION TO THE STUDY OF THE HISTORY OF MATHEMATICS. Sarton (Harvard U.P.).

D. The Teaching of Arithmetic

PSYCHOLOGY OF ARITHMETIC. Thorndike (Macmillan).

PSYCHOLOGY AND TEACHING OF NUMBER. Drummond (Harrap).

PSYCHOLOGY OF NUMBER. McLellan and Dewey (D. Appleton-Century Co.).

TEACHING OF ARITHMETIC. Monteith (Harrap).

THE ART OF TEACHING ARITHMETIC. Thompson (Longmans).

TEACHING OF ELEMENTARY MATHEMATICS. Smith (Macmillan).

GROUNDWORK OF ARITHMETIC. Punnett (Longmans).

THE CASE AGAINST ARITHMETIC. Renwick (Simpkin).

INTRODUCTION TO PRACTICAL MATHEMATICS. Saxelby (Longmans).

COURSE IN PRACTICAL MATHEMATICS. Saxelby (Longmans).

TEACHING OF MATHEMATICS IN ELEMENTARY AND SECONDARY SCHOOLS. Young (Longmans).

CONNECTION BETWEEN NUMBER AND MAGNITUDE. De Morgan.

MEN AND MEASURES. Nicholson (Smith, Elder)

MATHEMATICS FOR THE MILLION. Hogben (Allen & Unwin).

PSYCHOLOGY AND TEACHING OF ARITHMETIC. Wheat (Heath).

TEACHING OF ELEMENTARY MATHEMATICS. Godfrey and Siddons (Cambridge U.P.).

TEACHING OF PRIMARY ARITHMETIC. Suzzallo (Riverside Press, N.Y.).

INTRODUCTION TO MATHEMATICS. Whitehead.

QUEEN OF THE SCIENCES. Bell (Williams & Wilkins).

NATURE OF MATHEMATICS. Jourdain (People's Books O.P.).

NUMBER LAND. Bentzou and Hjuler (Dent).

MATHEMATICS IN LIFE AND THOUGHT. Forsyth (Univ. of Wales Press).

NATURE OF MATHEMATICS. Black (Kegan Paul).

E. The Lighter Side of Arithmetic

NUMBER STORIES OF LONG AGO. Smith (Ginn).

NUMBER PUZZLES. Smith (Ginn).

STORIES ABOUT NUMBER LAND. Ponton (Dent).

STORIES ABOUT MATHEMATICS LAND. Ponton (Dent).

THE PUZZLE KING. Seward (Lawley).

MODERN PUZZLES Dudeney (Pearson).

CANTERBURY PUZZLES. Dudeney (Nelson).

AMUSEMENT IN MATHEMATICS. Dudeney (Nelson).